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# Distribution and Variation in the Native Sheep of North America


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## Introduction

The purpose of this study of the native sheep of North America was in the first instance to examine the nature and extent of variation taking place within the members of the genus so limited, secondly to study the distribution of the several more or less homogeneous populations inhabiting different parts of the continent and finally to compile what information was available regarding the numerical status of mountain sheep in North America up to the close of 1939 and to record the artificial shiftings of populations from one locality to another through the instrumentality of man.

In the course of the study I have examined seven hundred and sixty-one specimens, which it is believed constitutes the bulk of the material available in America. More than half of these specimens are incomplete or fragmentary skulls and though of use to indicate the former presence of sheep, they provide no indication of the race involved, many more specimens are immature individuals from which but little distributional information may be derived. Thus, though the "specimens examined" list given at the end of a racial treatment may be long, the material of worth in a study of this type may be disappointingly meagre. Wherever specimens from marginal localities are of a nature to be unidentifiable, this fact has been indicated.

Because of their bulk, mountain sheep specimens are difficult to work upon. The collections are widely scattered across North America and it has been impossible to assemble even an adequate representation of all the populations in one place. However, these difficulties were overcome in large part by

the taking of numerous photographs, a series of twenty-two standardized measurements of skulls, and elaborate notes on color and other characteristics of skins. Ridgeway's "Color Standards and Color Nomenclature," 1912, was used throughout, all capitalized color terms refer to this work.

I have found that except in one or two instances significant differences in coat color between adjoining populations cannot be demonstrated. In no instance is an adequate series of external measurements available. Consequently the more precise parts of this investigation, as it applies to variation, deals with the skulls only and it is to the skulls I have resorted for most of the data on geographic variation. As large homogeneous samples as was possible both of male and of female skulls have been measured for each population and the resulting figures have been treated statistically and compared according to methods and formulae set forth by Simpson and Roe.

Geologically speaking the genus *Ovis* as represented in North America is a young one. There are no remains definitely identifiable as of *Ovis* known from the true Tertiary of this continent. Sheep remains are, however, known from the Kowak clays of Alaska (Frick: 1937), the Pleistocene River gravels at Last Chance Creek, Yukon (Lambe, 1912:347) and Washtuena Lake, Franklin County, Washington (Osborn, 1912:474) and doubtfully from Ohio, (*Ovis mammularis* Hildreth) Mexico and Nicaragua [Ovis ? scaphoceras (Cope)]. None of these is from deposits earlier than the middle Pleistocene.

It is generally conceded that Asia is the ancestral home of the group. On that continent remains of sheep identifiable with the modern *Ovis ammon* and *Ovis nahor* were found associated with human remains in the Choukoutien fauna; the genus *Ovis* is represented in the older (late Pliocene or early Pleistocene) Sanmenian fauna, and primitive sheep have been rported from the Tung Gur Miocene (Black et al 1933). *Ovis nivicola* of north eastern Asia, while possessing specific characters of its own, is more closely related to the North American sheep than are any of the other Asiatic species and probably represents the Asiatic descendant of the sheep ancestral to those of North America.

From this premise of Asiatic origin it is possible to imagine the sheep reaching North America by way of the Bering Sea land bridge in late Pliocene or early Pleistocene time, or perhaps crossing on the ice more recently. Sheep occur within sight of salt water on both sides of the Bering Sea (Nelson, 1887 and Allen, 1904.)

From Alaska the sheep would find almost continuous mountain chains extending southward down the coastline and through the interior of the continent. Along these migration routes the sheep spread until they reached their limits of tolerance for the various factors in the environment.

With the onset of the ice incursions characteristic of certain stages of the Pleistocene of North America, the development of the cordilleran ice cap would remove from available sheep territory that portion of the Rocky Mountains and coastal mountains lying between 62° north latitude and approximately 45° north latitude. It is currently acknowledged that land habitable by

vertebrates probably existed in northern Alaska throughout the ice ages. It is reasonable to suppose therefore that the formation of the ice cap during the successive ice ages divided the sheep population of North America into northern and southern groups. The northern, a small residual population restricted to northern Alaska; the southern occupying the main range of the Rocky Mountains south of the ice cap and spreading eastward into the isolated desert ranges and badlands, and westward into the Cascades and Sierra Nevada. Thus separated the two stocks evolved independently under radically different environmental circumstances producing ultimately in the north the thin-horned species *Ovis dalli* and in the south the bighorn, *Ovis canadensis*.

Any discussion involving movements of animals in relation to the Pleistocene ice ages of North America is always complicated by the at least four separate glacial and interglacial periods. During one or more of the latter it is possible that these divided populations made contact with one another with results impossible to determine.

The similarity of the environmental conditions under which *dalli* and *nivicola* have evolved may have been such as to foster somewhat parallel changes from the parent stock. At the same time the vastly different environment provided by the arid badlands and mountain ranges can easily be imagined as likely to foster the development of the southern population, *canadensis*, along somewhat different lines.

As the last ice recession once more made the northern mountains available as vertebrate habitats the sheep spread northward from the southern stock up the Rockies and up the Cascades. At the same time, or probably somewhat later, because in all probability the ice recession took place more slowly there, the northern stock began its southward invasion of new territory.

In the Rocky Mountain chain the two currents of invasion have reached the Peace River Gap at about 56° north latitude. The species *dalli* has extended its range as far south as the northern bank of the Peace River. The species *canadensis* is known to range to within perhaps one hundred miles or less of this gap from the southward.

In the west the intrusion of the coastal wet belt far up the Skeena Valley has probably effectively barred the way to further southward spread of *dalli* beyond 56 degrees while the replacement of the dry plateaus and peaks of the Cascade range in southern British Columbia by the more precipitous and more humid Coast Ranges effectively confines *Ovis canadensis* south of the 52nd parallel. The intervening four degrees of latitude are without a sheep population.

Severtzov and Nassonov, as cited by Sushkin (Journ. Mamm. 6 145) in their speculations regarding the origin of the North American sheep neglect the possibility of the survival of a northern population through the glacial periods. Instead they postulate an early colonization of North America from Asia, and during one of the interglacial periods a recolonization of northeastern Siberia from America. In this way they explain the apparent close relationship between *nivicola* and *dalli* as regards form of horns. This seems to me to assume a persistence of the land connection between Siberia and

Alaska until a much more recent date than we have any evidence for. It also implies the differentiation of *canadensis, dalli* and *nivicola* since the remigration of pre-*nivicola* stock to Asia and therefore after the elapse of a considerable period of glacial isolation in the early part of the Pleistocene.

The theory of double migration as put forward by these authors is based on their assumption that *canadensis* is nearer the primitive type than are the thin-horned northern species and gave rise to the latter. This premise was based on an apparent similarity of *canadensis* to *ammon*.

The true characteristics of *canadensis* as a species have been largely overlooked by European authors. Emphasis has been laid upon the heavy, close curled horns, short ears and long narrow muzzle of *canadensis*. Only one race possesses the short ears and close curled horns and that is *canadensis*, a race occupying a territory that would for the most part have been uninhabitable during the ice ages. The races occupying the more southerly mountain ranges, areas of probably fairly constant habitability, have long ears, together with more open horns. I have elsewhere shown that the ratio of orbital width to basilar length of Hensel is essentially the same in *canadensis* and *dalli* so that apart from certain minor cranial features the differences between *dalli* and *canadensis* are largely those of size of body and skull, and form of horn.

The reduced size of the rostral portions of the skull of *nivicola* together with the small rump patch seem to me to be undoubted primitive characters. I interpret the evidence as indicating a *nivicola*-like ancestor for all the American sheep; that *dalli* and *stonei* are the least specialized and *canadensis* the most highly specialized of the North American forms.

The status of *dalli* as a species distinct from *canadensis* rests largely upon size, horn characters and the absence of any apparent intergrades between the two. *Dalli* is smaller, and has horns of small basal circumference and great length, with the anterior surfaces strongly rugose, the orbital angle prominent, and often developed into a pronounced ridge overhanging the orbital surface of the horn.

It so happens that the only race of *canadensis* with range even approximately contiguous to that of *dalli* is in its external form and cranial characters less like *dalli* than any of the other races of the species. *Nelsoni* among the races of *canadensis* most nearly resembles *O. d. stonei* in size and gross dimensions. A comparison of skulls of these two races, with identical basilar length reveals the short narrow nasals, narrow rostrum and broad occiput, short tooth row and broad palate that characterize the skulls of all races of *dalli* in contradistinction to any race of *canadensis*.

The relationship of the American species of *Ovis* and their place in relation to the many Asiatic species has been the cause of considerable discussion. Lydekker (1902 and 1913) has considered all the North American sheep as conspecific with the *nivicola* of Kamchatka and includes that sheep and *borealis* as races of *canadensis*. At the same time he admits that these two races differ more from all the American sheep than do the latter from one another. Guillemard (P.Z.S. 1885: 675-678) considers *nivicola* distinct from the American sheep but says nothing to indicate that he had compared his

specimens of *nivicola* with *dalli*. Indeed he mentions only "*O. montana*." Biddulph (P.Z.S.1885) pointed out several characters held in common by the races inhabiting Alaska and Kamchatka and not possessed by the southern races of the American continent.

More recent work by Nassanov and by Sushkin acknowledge the southern group of North American races to be distinct from the thin-horned northern races but fail to distinguish specifically between the sheep inhabiting the opposing shores of the Bering Sea. Thus *dalli* and *stonei* are recognized as races of *nivicola* while the southern races of North America form the species *canadensis*.

I have had access to but few specimens from northeastern Siberia but what information I have derived from them supplemented by information given in the articles cited above leads to the conclusion that *nivicola* and *borealis* of northeastern Siberia are apparently more closely related to the sheep of Alaska than to other Asiatic forms. Despite this apparent consanguinity *Ovis nivicola* differs from *Ovis dalli* at least as widely as the latter does from *O. canadensis* and in consequence merits treatment as a separate species.

The most obvious cranial difference between *nivicola* and *borealis* and the American species is in the shortness of the skull, particularly the rostral portion, accompanied by great width across the orbits. This is reflected in the ratio of the orbital width to the basilar length. In three males of the average age of eight years from Gichiga, northeastern Siberia this ratio is 49.1 per cent whereas in comparable but larger series representing *dalli*, *stonei* and *canadensis* the ratio is 45.3 per cent, 45.3 per cent, and 45.1 per cent, respectively. Corresponding differences are to be seen in such other measurements as length of molar series and diastema.

The restricted size of the rump patch, this not extending above the level of the root of the tail, seems to me to be another rather fundamental character of *nivicola* as a species distinguishing it from *dalli* as a species.

The horns of Siberian specimens examined differ from those of *dalli*. They are smoother, the anterior face more nearly flat, the orbital angle more acute and the horns more compressed laterally when viewed in cross section.

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At the Museum of Vertebrate Zoology, Berkeley, California, I had the privilege of consulting Dr. C. Hart Merriam's personal file of notes and clippings. From this I gleaned much valuable information on former distribution.

## Variation in the Genus Ovis

Before entering upon the discussion of geographic variation in the genus *Ovis* it is necessary to examine the nature and degree of variation attributable to differences of sex, age and to the diverse conditions of environment and heredity involving each individual at a given locality.

The study of variation in the mountain sheep of North America is greatly hampered by the paucity of specimens available. In only one museum in America is there a series of specimens from any one general locality sufficient to form a basis for adequate statistical analysis of individual variation and in only one or two instances are series available to illustrate differences due to sex and age.

The following discussion is based in large part on a series of seven males and five females in the Museum of Vertebrate Zoology, Berkeley, California, preserved by Dr. R. M. Bond of the United States National Parks Branch from dead animals in Glacier National Park, Montana, an an additional seven males from adjacent Waterton Lakes Park, Alberta, preserved in the National Museum of Canada, and on a series of thirty males from Mount Chopaka, Washington, in the University of Kansas Museum of Zoology.

### Secondary Sexual Variation

Secondary sexual variation in the mountain sheep apparently differs in degree in the different parts of North America. As was found to be the case in the deer of the genus *Odocoileus* (Cowan 1936:160), the disparity in size between the sexes of the bighorn seems to be greatest in the northern part of the range, becoming progressively less toward the south. Too few data are available for the thin-horned sheep to render possible an analysis of size variation in the species.

Males in both the North American sheep are larger than females of equal age at any time after the age of one year. Size difference is even more noticeable in bulk measurements than in those of length. Adult rams will often weigh more than twice as much as adult ewes. This size disparity between the sexes extends to such bodily features as hoofs and skull but not apparently to length of tail and ears which average much the same in both sexes.

In any comparison of adult rams and ewes the most noticeable secondary sexual difference is in the horns. Those of the male are large, massive, and coiled in a more or less flat spiral on each side of the head; those of the female while varying greatly in shape are short, and thin, (see plate) directed generally upward and backwards but curving downwards to a varying extent toward the tips.

The male has a larger skull throughout particularly, as would be expected, in those parts associated with the support of the massive horns. Thus while basilar length of Hensel in nine adult female *canadensis* average 89 per cent

of that of twelve males of approximately equal age; the mastoid breadth averages only 82.3 per cent and the orbital breadth 85.7 per cent of that of the males. Least sex difference is exhibited by the part of the skull supporting the teeth, the upper molar series of the females averaging 98.5 per cent the length of that of the male series, the maxillary breadth 90.2 and the width of the palate at $M^3$ 94.6 per cent. Width of the basioccipital and width of the posterior extension of the palate, the two cranial features showing maximum disparity due to sex seemingly have no function in relation to the horns, in each the average for females is but 81.2 per cent that of the males.

I have been unable to detect any difference in coat color or pattern attributable to sex differences in the Bighorn in the more southerly parts of its range. Though too few specimens of ewes are available to be conclusive, specimens and field observations lead me to the conclusion that in the Canadian Rockies rams in fresh pelage are noticeably darker than the ewes and have the necks and heads less grizzled.

In a large series of *O. d. stonei* from the Iskoot River region the ewes are consistently paler than the rams and have the necks more grizzled and faces more nearly white. Acquisition of further material may show these differences to exist in all parts of the range.

## Age Variation

The rather inadequate data available indicates that bodily proportions and gross body size tend to increase gradually with age. This increase both in length and height at shoulder is rapid at first, slowing down between the ages of five and six years and perhaps ceasing altogether at eight to ten years of age. My evidence indicates that ultimate maximum size of skull and horns in any area is a composite result of genetic, and age factors, no doubt conditioned by environmental circumstances.

The ultimate maximum age in sheep is limited largely by the life span of the teeth. In three instances known to me sheep *(stonei)* shot in the early autumn were in poor and weakened condition apparently as the direct result of the loss of their teeth. One old ram shot on the Prophet River, B. C., in October, 1937, had no incisors and but four molariform teeth left. It seems certain that these rams would have died of starvation during the ensuing winter. Though age is hard to estimate in these very old individuals, as nearly as could be determined these were between fifteen and seventeen years old. Seton (1927, 3:570) mentions the death of a captive bighorn ram in Washington Zoo at the age of twenty years. There is no evidence to indicate that wild sheep customarily reach so advanced an age.

The horns in both sexes reflect the age of the wearer to greater or less degree. For the first four or five months of their lives young rams and ewes are apparently indistinguishable. In both the horns are just beginning to develop and project perhaps an inch or a little more from the head. The bony cores supporting the horns develop first toward the posterior margin of the frontal bone directly behind the orbit.

In the ewe they continue to occupy this general relation to the orbit

throughout life. However in the young ram of a year old the rapidly enlarging horn core has encroached upon the frontal bone above the entire orbit and caused elevation also of the region of the frontal suture between the horns. Up to the age of two years the horns of the young though heavier basally are essentially the same shape as those of the ewes. Though effected greatly by individual variation the horns of a five year old ram have usually reached the bottom of the downward swing and succeeding annual increments tend to bring the points of the horns further and further anteriorly and dorsad on each side of the face.

The horns of the genus Ovis are permanent structures added to each year at the base only. As they are primarily secondary sex characters associated fundamentally with combat in the males growth ceases during the breeding season and for a period of a few months before and after this period. This cessation of growth for a part of each year leaves a pronounced sulcus or ring around the horn in both sexes. It has been suggested that food shortage rather than physiological influences connected with the breeding season is the causative factor in the appearance of these annual growth checks on the horns. As a corollary to this theory the horn check on sheep inhabiting northern or high altitude ranges should represent the winter months, while those on horns of desert-inhabiting sheep should represent the dry season. I have no evidence to support one theory over the other, but analogy with the deer and with the Prong buck would tend to support the fotmer, namely that cessation of growth is primarily associated with reproductive activities.

During the first three years the ram's horn-growth is rapid and the periods of quiescence short so that the annual checks are inconspicuous. After the age of five years however the annual increment becomes progressively less and the growth checks more apparent until eight or ten years of age, subsequent to which in the bighorn the annual increment is so slight that it is often impossible to distinguish the growth rings. In males of the thin horned sheep however growth seems to persist for a greater number of years. I have examined a number of heads showing twelve and thirteen well defined checks and two with fifteen distinguishable as well as some increment in addition.

Throughout this paper these checks have been taken to indicate age in

TABLE 1.—Average, minimum and maximum values of skull dimensions of *O. c. canadensis* males of two different age classes.

| | | Basilar length | Orbital width | Zygomatic width | Maxillary width | Mastoid width |
|---|---|---|---|---|---|---|
| 5-6 years | 7 | 282(272-290) | 125(117-132) | 134(123-140) | 92(88-96) | 95(91-100) |
| 10-11 yrs. | 3 | 285(282-291) | 129(124-132) | 136(132-140) | 93(90-98) | 99(97-101) |

| | | Width of palate at M3 | Upper molar series | Basal circumference of horn | Length of horn |
|---|---|---|---|---|---|
| 5-6 years | 7 | 57(52-62) | 87(80-91) | 372(351-385) | 775(642-867) |
| 10-11 yrs. | 3 | 54(51-56) | 84(81-86) | 380(366-395) | 937(860-1030) |

years, allowance has been made for the first year's growth that in older rams is often broken off.

With each year, the horn not only increases in length but also in basal circumference and, in case where the tips are everted, in spread between the tips. As in the case of increment in length, the increase in basal circumference and spread (where such takes place) becomes progressively less with age and ceases altogether.

Horns of ewes grow rapidly for the first three or four years, slightly in the fifth and sixth years and practically not at all thereafter. There is apparently some geographic correlation in this, the horns of the female in the more southerly races of bighorn grow faster and for a greater number of years than those of the northern.

Over much of the range of the bighorn it is unusual for a ram over seven or eight years of age to have the horn tips entire. Often these are splintered, sometimes worn smoothly round. This is particularly evident in the Rocky Mountains and in the races living in the desert ranges. The sheep inhabiting the Sierra Nevada - Cascade Mountain chain do not exhibit this phenomenon so frequently. It is rare in the thin-horned sheep.

The explanation of this wearing away of the horn tips is still unknown. Sheldon is confident it is the result of the strenuous combats between rams. Ober is convinced it is the result of using the horns to dig for various food items, others have suggested that the rams wear them off accidentally or on purpose because they interfere with vision. A further suggestion is that the weathering is an inherent property of the horns in this species. So far as I have been able to learn bighorn rams raised in captivity seldom lose the tips of their horns, a fact that might tend to eliminate the latter theory.

A further age character in the horns, one that has upon occasion been erroneously used as a racial character, is the projection onto the face of the orbital corner of the horn sheath. There is great individual variation in this character in any given age group but in general it can be said that in bighorn up to five or six years of age the frontal margin of the horn is almost straight while with advancing years the orbital corner of this margin grows further and further down onto the face, rendering the angle between the frontal and orbital margins more and more acute.

Age variation in the skull is pronounced between the ages of one year and five years, plate 3 will illustrate in a general way the changes taking place in that growth period. From maturity, at the age of approximately five years, skulls of males increase slowly in all features except length of tooth rows, and width of palate. These become accordingly relatively less in older individuals. Table 1 compares average measurements of a series of seven rams between five and six years old and three rams between ten and twelve years old from the same general locality.

Beginning at the age of five years fusion of the various bones comprised in the skull progresses through a fairly regular course until the skulls of rams

ten years old or older have at least the dorsal elements completely ankylosed. I have attempted to coordinate the progress of this coossification with the age at which it takes place. Undoubtedly there is considerable variation between individuals but the following outline of the events is as nearly accurate as available data permits.

At five years the frontal suture starts to become obliterated and by the sixth autumn the two frontals are almost completely coossified. At the same time the posterior ends of the nasals unite with the adjoining margins of the frontals.

Between six and seven years of age the fronto-parietal suture becomes fairly well ankylosed, and the fusion of the parietals with the supraoccipital begins at the mid-point dorsally and progresses laterally to become complete before the eighth autumn is reached. The next sutures to become obliterated are the frontomaxillary and jugomaxillary. Fusion here takes place gradually throughout the eighth and ninth years, is usually fairly well completed by the ninth autumn and always complete by the tenth autumn. In the ninth and tenth years also the jugosquamosal suture becomes ankylosed being completely obliterated by the tenth autumn.

At six years and also at seven years there is no interpalatine or intermaxillary fusion on the palate, but as the eighth and ninth years are reached the mid-palatal suture becomes progressively narrower, and in approximately the tenth year it is represented by an obscure line of slightly porous bone bearing a thin ridge down the mid-line of the palate.

From the sixth year on fusion of the nasals *inter se* and with the frontals first and later with the maxillaries progresses gradually from posterior to anterior. I have seen no animal in which the nasals are fused to the maxillaries throughout the length of their contact, or united at all with the premaxillaries.

A somewhat similar but less pronounced and complete series of events characterizes the ageing of the ewe, but data are insufficient to permit establishment of any correlations.

Changes in color and nature of the pelage between birth and assumption of the mature pelage are discussed elsewhere. I have been unable to distinguish any color changes attributable without doubt to age once maturity is reached.

## Tooth Succession

At birth the dentition of *Ovis* is represented by the entire deciduous series, including the incisiform canine (lower); the second and third upper and lower premolars and the anterior segment of the upper and lower fourth premolars. The latter teeth complete their eruption shortly after birth. Between four and six months subsequent to birth the first molars start to appear; the lower generally slightly preceding the upper. By seven to eight months the entire lower and anterior segment of first upper molar is functional, the posterior segment of the upper almost so. At an age of from twelve to fifteen months the second lower molar has the anterior segment pigmented, the posterior just showing, the upper molar beginning to erupt. About eighteen months after

birth the second upper and lower molars have joined the functional tooth row. In some instances they are not completely functional until the age of twenty-four months. At about the same time the first incisor is shed and replaced by its permanent successor. The growth and movements of the incisors are the same in *Ovis* as has been outlined for *Odocoileus* (Cowan 1936).

Subsequent tooth replacement and the addition of the third molars is an extended process. By the age of approximately thirty-six months first the third premolars and then the second premolars have been replaced by their permanent representatives. In this the upper teeth in each case slightly precede the lower. At about this same age the anterior cusps of the upper and lower third molars make their appearance, followed in the next six months by the posterior cusps. The third molars are usually functional at or before forty-two months. At this time also the fourth premolar is shed and replaced, as also is the second incisor. At the age of forty-two months then, the permanent dentition is complete save for the third incisor and the canine. These are usually replaced during the next six months, that is before the sheep is four years old; in some instances however they persist until the animal is almost four and a half years of age.

## Individual Variation

Under this heading I include all departure of the individual from the mean of the species not known to be associated with sex, age or geographic point of origin. Thus it will include variations resulting from heterozygous inheritance and mutations as well as such as are induced by the action of the environment upon the individual during the course of its life.

The accompanying tables present the organized data relative to variation in a series of twelve male *Ovis c. canadensis* from Glacier National Park, Montana, and adjacent Waterton Lakes Park, Alberta, nine females of the same race from the same general area and twenty-nine male *O. c. californiana* from Mount Chopaka, Washington. All individuals measured are five years of age or over. The low coefficient of variability for the various cranial features measured serves as an indication of the low variability in these features attributable to age and individual subsequent to the age of five years.

On the other hand the extreme variability of the measurements of horn form would point to either age, individual, or both as associated with extensive variation in these organs. Data given elsewhere in this paper points to the responsibility of both these factors in producing the high coefficient of variability.

Several authors have stated that where possible female skulls should be used in studies of geographic variation because of their smaller variability. Comparisons of the values of V for the series of male and female skulls reveals that in the females the coefficient of variability is less than that for corresponding measurements of male skulls in just half the instances. There is consequently no basis for the assumption of lower variability in the female. The greater degree of obliteration of sutures that characterizes advanced age

TABLE 2.—Cranial measurements of *O. c. canadensis* females from northern Montana and southern Alberta.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 9 | 252± 2.22 | 242–262 | 6.27 ± 1.47 | 6.671 | 2.49 ± .582 |
| Nasal length | 9 | 98± 2.24 | 89–110 | 6.340± 1.54 | 6.723 | 6.43 ±1.47 |
| Nasal width | 9 | 38± .82 | 35–42 | 2.285± .54 | 2.412 | 6.00 ±1.42 |
| Orbital width | 9 | 108± .71 | 103–110 | 2.00 ± .473 | 2.12 | 1.85 ± .424 |
| Zygomatic width | 9 | 120± .80 | 116–125 | 2.26 ± .535 | 2.4 | 1.88 ± .445 |
| Maxillary width | 9 | 83± 1.01 | 79–88 | 2.86 ± .678 | 3.041 | 3.45 ± .815 |
| Mastoid width | 9 | 79± .707 | 76–83 | 2.00 ± .474 | 2.12 | 2.55 ± .599 |
| Palatal breadth at M3 | 9 | 53± .676 | 50–56 | 1.916± .452 | 2.030 | 3.62 ± .853 |
| Palatal br. at Pm2 | 9 | 32± .98 | 27–36 | 2.769± .654 | 2.936 | 8.65 ±2.04 |
| Post palate | 9 | 28± .725 | 24–31 | 2.05 ± .483 | 2.18 | 7.33 ±1.73 |
| Palatal length | 9 | 95± 1.85 | 86–104 | 5.229± 1.27 | 5.45 | 5.50 ±1.31 |
| Upper molar series | 9 | 85± 1.38 | 78–87 | 3.902± .92 | 4.137 | 4.58 ±1.08 |
| Prealveolar length | 9 | 81± 1.54 | 78–90 | 4.359± 1.06 | 4.623 | 5.38 ±1.27 |
| Post dental length | 9 | 87± 1.63 | 82–95 | 4.00 ± .945 | 4.24 | 4.60 ±1.09 |
| Width of basioccipital | 9 | 26± .445 | 24–28 | 1.292± .305 | 1.371 | 4.96 ±1.17 |
| Width of premaxillae | 9 | 28± .472 | 27–30 | 1.334± .315 | 1.414 | 4.77 ±1.15 |
| Basal circum. of horn | 9 | 129± 4.76 | 110–154 | 13.46 ± 3.17 | 14.29 | 10.28 ±2.43 |
| Circumference of core | 5 | 109± 2.58 | 110–115 | 5.177± 1.67 | 5.788 | 4.74 ±1.51 |
| Length of horn | 9 | 273± 9.30 | 222–310 | 26.23 ± 6.22 | 27.81 | 9.61 ±2.36 |
| Spread of horns | 9 | 333±18.78 | 192–420 | 53.0 ±12.51 | 56.3 | 15.95 ±3.76 |

* In this and other tables N=number of specimens; M=arithmetic mean and its standard error calculated on the basis of N-1; R=range of variation; σ=standard deviation and its standard error; σ′=standard deviation calculated on the basis of N-1; V=coefficient of variability and its standard error.

in males and not so much in females, does however make female specimens more desirable in certain cases.

Individual variation is particularly noticeable in the horns of both sexes, Plate 1 will illustrate the degree to which it may be represented in ewes from the same locality. In males it may involve not only length and basal circumference of the horn but the angle at which the horn leaves the skull, the extent of the upward portion of the spiral as well as the curvature of the arc of the spiral and the pitch of the spiral which in turn governs the degree of divergence of the horns.

Sheldon (1911:300) makes some interesting comments upon variation in horns among the thin-horned sheep. He states that the diverging type of horns is found in all localities where sheep exist but that everywhere the narrow type is more abundant. He found that both types sometimes existed in the same band while sometimes all of one band would be of one type. What is true of the comparative divergence is true also of basal circumference and length. Very large horns are more common in those districts where the diverging type of horn is most abundant.

Besides this what may be termed normal variation in the horns certain more

radical variants occur. Unaccountably dwarfed individuals have been taken on several occasions and have found their way into museums. One such provided the type specimen of *Ovis sheldoni*. I suspect that another led to the erroneous describing of the sheep of the Similkameen district of British Columbia as a small species *O. similkameenensis* Millais. A similar specimen is present in a

Table 3.—Cranial measurements of *O. c. canadensis* males from Glacier Park, Montana, and Waterton Lakes Park, Alberta.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 12 | 283 ± 1.97 | 270–294 | 6.82 ± 1.4 | | 2.42 ± .494 |
| Nasal length | 11 | 117 ± 1.01 | 108–125 | 3.36 ± .717 | | 2.87 ± .612 |
| Nasal width | 11 | 52 ± 1.53 | 43–57 | 5.65 ± 1.108 | | 9.74 ± 2.08 |
| Orbital width | 12 | 126 ± 1.69 | 121–132 | 5.86 ± 1.20 | | 4.65 ± .951 |
| Zygomatic width | 12 | 134 ± 1.345 | 123–140 | 4.66 ± .955 | | 3.49 ± .712 |
| Maxillary width | 12 | 92 ± .957 | 88–98 | 3.32 ± .679 | | 3.61 ± .740 |
| Mastoid width | 12 | 96 ± .986 | 91–101 | 3.41 ± .699 | | 3.56 ± .727 |
| Palatal breadth at $M^3$ | 12 | 56 ± .880 | 51–62 | 3.05 ± .623 | | 5.44 ± 1.13 |
| Palatal br. at $Pm^2$ | 12 | 36 ± .629 | 31–39 | 2.18 ± .446 | | 6.06 ± 1.24 |
| Width of post palate | 12 | 32 ± .398 | 29–35 | 1.38 ± .282 | | 4.32 ± .885 |
| Palatal length | 12 | 103 ± 1.63 | 94–111 | 5.62 ± 1.15 | | 5.46 ± 1.12 |
| Lgth. upper molar ser. | 12 | 86 ± 1.18 | 78–91 | 4.07 ± .835 | | 4.75 ± .973 |
| Prealveolar length | 12 | 88 ± .954 | 82–93 | 3.30 ± .676 | | 3.76 ± .767 |
| Post dental length | 12 | 99 ± 1.38 | 90–107 | 4.77 ± .976 | | 4.83 ± .99 |
| Width of basioccipital | 12 | 32 ± .50 | 29–35 | 1.73 ± .354 | | 5.42 ± 1.11 |
| Circumference of horn | 12 | 373 ± 3.36 | 351–395 | 11.65 ± 2.38 | | 3.125 ± .640 |
| Circumference of core | 7 | 320 ± 4.64 | 310–345 | 12.25 ± 3.28 | | 3.84 ± 1.03 |
| Length of horn | 12 | 826 ± 28.8 | 642–1030 | 99.52 ± 20.4 | | 12.08 ± 2.48 |
| Spread of horns | 12 | 464 ± 17.15 | 395–570 | 59.4 ± 12.16 | | 12.82 ± 2.62 |

TABLE 4.—Cranial measurements of *O. c. californiana* males from Mount Chopaka, Washington.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 28 | 269 ± 1.09 | 253–282 | 5.75 ± .770 | | 2.12 ± .405 |
| †Nasal length | 6 | 116 ± 2.60 | 103–107 | 5.82 ± 1.68 | | 5.6 ± 1.45 |
| †Nasal width | 8 | 51 ± 1.11 | 46–58 | 2.95 ± .740 | | 5.80 ± 1.45 |
| †Orbital width | 11 | 128 ± 1.55 | 116–131 | 4.90 ± 1.05 | | 3.98 ± .850 |
| Zygomatic width | 28 | 135 ± .690 | 126–142 | 3.65 ± .488 | | 2.70 ± .51 |
| Maxillary width | 29 | 93 ± .647 | 87–97 | 3.48 ± .457 | | 3.74 ± .492 |
| Mastoid width | 29 | 93 ± .575 | 87–98 | 3.10 ± .405 | | 3.32 ± .436 |
| Palatal breadth at $M^3$ | 29 | 57 ± .362 | 54–62 | 1.95 ± .256 | | 3.42 ± .449 |
| Palatal br. at $Pm^2$ | 29 | 35 ± .525 | 31–41 | 2.83 ± .370 | | 8.07 ± 1.06 |
| Upper molar series | 29 | 88 ± .540 | 81–94 | 2.91 ± .381 | | 3.30 ± .434 |
| Prealveolar length | 28 | 87 ± .564 | 79–93 | 2.98 ± .398 | | 3.43 ± .45 |
| Post dental length | 29 | 86 ± .875 | 75–97 | 4.70 ± .619 | | 5.48 ± .720 |

† Series from southern British Columbia and Mount Chopaka, Washington.

series of normal individuals from Lillooet, B. C., in the Provincial Museum. The single horn sheath of a ram showing nine growth rings (M. V. Z. No. 42090) from White Pine Co., Nevada, is the smallest adult mountain sheep horn examined. It measured 263 mm. in basal circumference, 634 mm. in length around the curve. Normal rams of *Ovis c. nelsoni* of similar age would have corresponding measurements of approximately 370 mm. and 850 mm. Another dwarf ram from one hundred and twenty-five miles southeast of Yuma, Arizona, is in the Philadelphia Academy of Sciences collection.

Perhaps in no feature is variation between individuals more apparent than in coat color and pattern. This is particularly striking in life when large bands of ewes can be seen at one time. On August 30, 1929, in the Rocky Mountains north of Banff, Alberta, I watched a flock of thirteen ewes and lambs for over an hour. In it were individuals of a dark chocolate brown, and alongside, others of a dingy drab and yet all in the fresh fall pelage. Individual variation in coat color is so great that in any race of which series in moderately fresh pelage have been available it entirely overlaps the range of variation of all the other adjacent races.

Coupled with this in its ultimate effect is a widespread in time of molt. Consequently at any one time in a band of sheep will be not only individuals with intrinsically different coat color but with their pelage showing in varying degrees the result of the rapid bleaching produced by exposure to the action of the sun, wind, rain, snow and mechanical abrasion of the environment. Variation in coat color and in pattern is probably nowhere more apparent than in the extensive area in northern British Columbia and the Yukon between the ranges inhabited by the black sheep of typical *stonei* type and the white sheep of *dalli* type. In parts of this area may be found flocks of sheep containing individuals ranging in color from almost white to almost black. In this instance the proportion of dark pigmented individuals in the flock and the darkness of these individuals varies geographically.

In consequence of these factors coat color *per se* is of almost negligible value as a racial character. While average differences can be shown to exist between the populations of certain areas many of the described races are represented by so few specimens that it is impossible to establish anything approaching an accurate idea of coat color.

Differences of color pattern not attributable to sex, age or geographic position are presence or absence of white on the underparts, and in many instances extent of the dorsal stripe, division of the rump patch by the tail stripe, and color of muzzle (light or dark).

## Geographic Variation

The extermination of sheep of the species *O. canadensis* has proceeded to such a degree that a study of geographic variation based on present distribution of this sheep in North America would inevitably lead to many erroneous conclusions. We have to concern ourselves more with the distribution as it existed upon the advent of the white man into its territory.

This species of North American sheep has proven itself exceedingly adaptable. Its range of temperature tolerance is from 55 degrees to 60 degrees below zero to perhaps 120 degrees above zero in the shade. It has in many places learned to exist with a minimum of available water (Ober 1931:27) and Merriam (1916:129) yet where such is abundant the sheep drink regularly. The essential common denominator in all the extent of this distribution appears to be dryness particularly in the winter and spring months. In the northern parts of its range though the snowfall may be heavy the lower temperatures produce a condition of drought almost as real as the absence of precipitation in the desert regions. Comparison of the range maps of the bighorn and precipitation maps of North America shows the western limit of the range of this species to coincide remarkably with the isoheyets for 20 inches rainfall in December, January and February and with the closely similar one of 40 inches average annual rainfall. These run in a north and south direction along the east side of the Sierra-Cascade mountain chain.

This correlation may of course be a secondary one for under the condi tions of higher humidity existing on the western slopes of that mountain chain the winter snowfall is heavy and the lower elevations forested rather than open. In this connection it is significant that sheep are spotty in distribution on the more humid western slope of the Rocky Mountains in Canada and have a relatively continuous distribution on the drier east slope. Statements (Grant 1904:198) to the contrary notwithstanding sheep do not now occur and probably have not occurred within recent time on the Selkirks or other ranges west of the Rockies in British Columbia until the Cascades are reached.

The presence of sheep in nearly all the isolated mountain ranges of the southwestern desert tract renders it likely that under conditions of abundance sheep habitually crossed extensive plains to any other range within their circle of vision. I have no evidence of sheep traversing even short tracts of dense forest in order to pass from one mountain range to another.

The ease with which sheep swim the Athabasca River, even in spate leads me to believe that even moderately large and swift rivers would be of little effect as barriers to distribution.

In consequence of this vagility and adaptability it is unlikely that any sheep population lived under conditions of complete physical isolation. However it is to be supposed that marginal conditions might produce conditions of relatively effective isolation; and that areas in which sheep were living under conditions of maximum departure from the optimum might foster the survival of sheep differing on the average from the mean of the entire population living under more favorable conditions.

A glance at a map showing type localities of populations supposedly differing sufficiently to warrant the application of separate names shows that of the twelve races now named four, *canadensis*, *californiana*, *nelsoni* and *mexicana*, occupy the bulk of the species range. Of the other nine names six, *auduboni*, *texiana*, *weemsi*, *cremnobates*, *similkameenensis* and *sheldoni*, have been applied to populations living under marginal conditions.

The very small number of specimens for which external measurements are available makes it well nigh impossible to deduce from them general trends that have any reliability. However in as much as indication found in the few external measurements are for the most part substantiated by the more extensive skull data it is here given for what it is worth.

Apparently *canadensis* rams average larger than do those of any other race. The females of *canadensis* however, differ very little from those of the more southerly races, it follows therefore that in the Rocky Mountain range generally, there is an increase in size of males toward the north and a resulting increase in sexual disparity from south to north. In the almost complete absence of external measurements of *californiana* from Washington and British Columbia it is not possible to discuss the situation in the Cascade-Sierra Nevada mountain chain.

Comparison of four representative skull measurements, basilar length, orbital breadth, maxillary breadth and length of upper tooth row, reveals a similar condition in the Rocky Mountains as regards length of skull as was revealed by gross body length. *O. c. canadensis* of the northern Rockies has the skulls of males the longest found in the species but the width measurements do not vary analogously. Females of *canadensis* as regards basilar length and orbital width are indistinguishable from female *mexicana* of the Mexican boundary region.

In general toward the southern margin of the range the sheep have longer ears, heavier tooth rows and broader rostra.

No long-range variation of importance takes place in the Cascade-Sierra Nevada chain.

In the northern British Columbia, Yukon and Alaska range of *Ovis dalli* gross body size, as well as length and breadth of skull and length of tooth rows has the inverse relation to latitude and decrease toward the north. In this species also intensity of pigmentation is greatest in the southern part of the range, least in the north.

There is fairly definite indication that intrinsic coat color varies latitudinally, averaging darker in the northern parts of the species range, paler in the southern parts. However, as has already been stated individual variation in color and seasonal wear and bleaching of the pelage are so pronounced that even average differences in color are hard to discern.

As already shown length of pelage when fully developed is apparently controlled largely by winter temperatures acting on each individual annually. There may, however, be a difference in maximum limits set by inheritance that very meagre data has not revealed.

The Cascade Mountains east of the height of land from the Chilcotin district of British Columbia southward and the Sierra Nevada south approximately to Yosemite Park, California, are occupied by a race of sheep of moderate size with in the nothern parts the body color between Benzo Brown and Drab in September and early October specimens; relatively short ears and tail, horns moderately heavy at the base, tapering rapidly to the tips, which

are often entire, sometimes slightly rounded; moderately spreading. Only three adult male specimens are available for the Sierra Nevada region of California. These are virtually identical with the northern series, except for shorter nasals, a very slight (4 mm.) decrease in the mean orbital width, and possibly a paler body color. The actual differences between skulls of males of Cascade-Sierra populations and Great Basin populations is small and the transition from one type to the other takes place abruptly at the southern end of the Sierra Nevada.

Here in the mountain ranges of southern Nevada, the Inyo Mountains, San Bernardino and San Jacinto Mountains as well as many of the ranges bordering Death Valley and the Colorado Desert of California is a population the females of which differ from those of the Sierras and Cascades in smaller size, skull shorter with orbital width, zygomatic width, mastoid width, least palatal length and diastema significantly smaller, longer ears and tail and apparently a paler basic coloration. The horns do not taper so rapidly, have a slightly wider spiral giving greater lateral spread and generally have the tips broken off in adult males. The horns of the ewes are on the average much longer and heavier than in the northern populations.

In southern Arizona, Texas, and northern Mexico, the sheep exhibit another combination of characters. The tooth rows of males are longer, the maxillary and palatal breadths greater, and the skull size in general less, the horns tend to be more tapering and though individual specimens give the impression of being heavier, the series I measured average a little lighter and have horns slightly less divergent. A more detailed discussion will be found in the treatment of *nelsoni*, p. 559.

In Lower California the sheep are of the desert type with short skulls, heavy teeth and broad rostra but they have carried to its maximum the development of horns in the female. A further development not found in the sheep of other parts of North America is the presence of pronounced lateral ridges on the palatine processes of the premaxillae. Both these characters become more pronounced from north to south. Only four April specimens are available from the southern tip of Lower California and I have seen no strictly comparable material from the northern part of that province. However after due allowance has been made for fading there is apparently a darkening of pelage color toward the south.

Along the valley of the Colorado River the open horned, heavy toothed, pale, desert sheep of Arizona gradually gives way to the close horned, light toothed, dark colored sheep inhabiting the Rocky Mountains. The trend is so gradual that it is impossible to draw an arbitrary line between the two. However the Rocky Mountains from Colorado, Utah and Wyoming north through southern Idaho, Montana and into Alberta and British Columbia is inhabited by the most highly specialized population. In its large size, closely curled horns, with very heavy basal circumference, large skull without prominent orbits, this population differs more radically from the hypothetical ancestral type than do the sheep of any other part of North America.

Sheep formerly occurred in the Tucannon River region of southeastern

Washington, also in Grant and Douglas counties, Washington, on the east side of the Columbia River. Sheep still exist in the Wallowa Mountains of northeastern Oregon. I have been unable to locate identifiable material from these areas but it seems probable that they were inhabited by sheep of the Rocky Mountain type.

Sheep were once abundant in the badlands bordering the Missouri River in North and South Dakota. Only seven partial or complete specimens are available from this entire region, these from North and South Dakota. Two males in this series have the tooth rows averaging six per cent longer and placed somewhat more obliquely than is usual in sheep from the Rockies. Two females differ from the Rocky Mountain type in broader rostrum and occiput.

The details of geographic variation in color of the thin-horned sheep have been admirably set forth by Sheldon (1911). It is of no avail to repeat them here as little can be added to his account. Suffice to say that in the Endicott Range, the Mackenzie Rockies, the Alaskan Range, Mutzat Range, Chugach Mountains and St. Elias Range all of Alaska and the Yukon the sheep are predominantly white some few having dark hairs in the tail. In the region south of the Stikine River and north at least to the Liard River the sheep are for the most part dark in color though lighter individuals become progressively more numerous in anortherly direction and are abundant around Dease Lake, B. C.

The mountains intervening between these two areas are inhabited by bands of sheep including almost every degree of intergradation between the two extremes except that the farther north the locality in general the greater the proportion of light individuals.

Contrary to the condition in *canadensis* the thin-horned sheep exhibits size reduction toward the north, and accompanied by a shorter though relatively broader skull. Further discussion of these features is given in the treatment of *O. d. dalli.*

Dr. R. M. Bond has called my attention to a seeming geographic correlation in degree of development of the burr on the horn cores. In general he finds that the burr is best developed in the far north range of *dalli* and *stonei* and becomes progressively less so southwards. Many specimens of *nelsoni* and *cremnobates* have no burr at all. This structure may be a reaction to low winter temperatures as the degree of its development seems to parallel closely a descending order of winter temperatures.

### Molt and Pelage

There is no evidence of more than a single annual molt. As early as April in some of the southern races the presence of the new hair can be detected by separating the worn outer hair of the winter coat. Specimens of *weemsi* taken in Southern Lower California on April 13, 1936, illustrate this well; in these the new hair forms a complete undercoat to a degree that its color is readily discernible.

The molt usually begins on the head and back, proceeds down the neck

and legs and culminates on the sides and abdomen. However the nature of the habitat conditions this to some degree. Individuals inhabiting areas where there is some brushy cover tend to molt the old hair on the sides and abdomen early as a result of the rubbing of these parts on the bushes.

In some instances the old hair comes loose in masses but in most cases the molt is more diffuse and about the end of May or early June much of the old hair is shed, the rest becomes broken off close to the base and remains in position while the new hair comes in between.

In *stonei* the light colored bases of the broken old hairs together with the dark tips of the growing pelage at this time give a light pepper and salt effect to the dorsal region.

At this stage particularly in the northern races the heavy undercoat of true wool becomes visible and even in the desert races it becomes matted and quite evident. The matting increases in the course of two or three weeks and finally large patches of this fleece become detached and shed.

In a specimen taken February 23, 1902, at Cerro Chino, Chihuahua, Mexico, (Amer. Mus. No. 17957) the winter coat is about one inch long. Already the wool is coming out and appearing on the surface as felted mats.

As in many, if not all, ungulates physical condition undoubtedly effects time of moult. Mature rams on the average moult earlier than ewes with young or animals of either sex in poor condition.

Davis (1938:91) states that in the Yellowstone Park region rams and yearling ewes had completed the molt by early July, while the older ewes were still molting. In general the molt is complete by the end of August but a single female from Inyo County is apparently just beginning to molt in October.

In the northern races at least, particularly in *dalli, stonei* and *canadensis* in the Canadian Rockies the hair grows slowly throughout the summer and fall and almost until midwinter. December skins from near Atlin, B. C., have the long hair of the back up to four inches in length and underlying this a dense fleece of wool. On the back of the neck and on the nape the hair frequently forms a pronounced mane.

In *dalli* the short summer coat becomes stained either yellowish or grayish soon after it appears. Staining depends on the color of the earth of the bedding grounds and varies accordingly. With the onset of the winter snows the staining is rapidly lost.

Under the rigorous environmental conditions of the southern desert tracts the pelage of the sheep rapidly becomes faded and worn. In these southern races also growth apparently persists until November or December, but by late summer the hair is so bleached by the sun as to display little of its true color.

When first born the lambs of all races are clothed in a fine coat of fairly long woolly hair. This is, in all save *dalli,* very much lighter in color than in the adult, and is usually some shade just off white. A lamb of the race *canadensis* born in the New York Zoological Garden and now No. 48905

Amer. Mus. has the entire body covered with woolly hair up to three-quarters inch in length and colored between Tilluel Buff and Vinaceous Buff, very slightly darker on the lower legs; rump patch and underparts are white in the usual pattern.

A lamb of the race *cremnobates* from St. Louis, Lower California, August 12, is somewhat darker, the very short pelage of its first fall coat is almost Avellaneous, darkening along mid-line of back, on tail, crown, and on outside of lower legs. The underparts are soiled whitish.

A September lamb of the race *stonei* from Iskoot River, B. C., in the Provincial Museum is paler than adults at the same time. The general body color is about Light Drab paling to white on the head, neck, underparts and rump patch. A pronounced narrow stripe of Benzo Brown extends from between the horns down the back of the neck and shoulder, diffuses and all but disappears on the saddle to become better defined on the rump where it is continuous with the dark tail stripe. The lower legs are predominantly grayish white with darker areas over the joints at knee and hoof.

Except for being somewhat finer in texture and in some observed instances a little paler the first fall pelage does not differ from the corresponding adult pelage in color or pattern.

**Definition of Measurements**

Basilar length: Greatest distance between inferior lip of foramen magnum and tip of premaxillae on mid-line.

Greatest length of nasals: Greatest distance from anterior margin to posterior margin of left nasal unless this is broken or otherwise malformed.

Width of nasals: Greatest combined width of nasals.

Orbital width: Least distance in straight line taken with calipers resting in notch on orbital rim at lower edge of lachrymal bone.

Zygomatic width: Greatest distance between external margins of zygomatic arches taken on jugo-squamosal suture.

Maxillary width: Least distance across rostrum behind maxillary protuberances.

Mastoid width: Greatest distance across occiput with calipers resting on external (lateral) surfaces of paroccipital processes.

Palatal breadth at $M^3$: Greatest distance across palate with calipers resting in re-entrant notch on lingual side of $M^3$.

Palatal breadth at $Pm^2$: Least distance across palate between alveoli of first premolar.

Post-Palatal width: Least palatal width posterior to third upper molars.

Palatal length: Least distance from posterior margin of anterior palatine foramen to posterior margin of palate.

Upper molar series or upper tooth row: Greatest alveolar length of combined upper molars and premolars.

Lower molar series: Greatest alveolar length of combined lower molars and premolars.

Prealveolar length: Least distance between alveolus of second upper premolar (first tooth of upper series) and gnathion.

Post dental length: Least distance between alveolus of third upper molar and anterior margin of paroccipital process on same side.

Width of basioccipital: Least width of this element between foramina ovale.

Width of premaxillae: Greatest width of combined premaxillae opposite anterior end of anterior palatine foramina.

Circumference of horn: Least circumference of base of right horn measured on an even plane touching the part of the margin farthest removed from the skull.

Length of horn: Measured round the spiral from orbital corner to tip of right horn unless that is malformed.

Circumference of horn core: Measured around the burr as nearly as possible at right angles to the axis of the core at that point.

Spread of horns: Greatest distance between tips of horns.

### *Ovis dalli dalli* Nelson—DALL'S SHEEP

*Ovis montana dalli* Nelson, Proc. U. S. Nat. Mus. **7**, 1884: 13; Turner, Contrib. Nat. Hist. Alaska, 1886: 203; Russell, Expl. in Far North 1898:236. Lyon & Osgood, U. S. Nat. Mus. Bull. 62; 1909: 10.

*Ovis montana Dalli* True, Proc. U. S. Nat. Mus. **7**, 1884: 592.

*Ovis canadensis dalli*, Nelson and True, Nat. Hist. Coll. Alaska, 1887: 282; Lydekker, Wild Oxen, Sheep and Goats, 1898: 219; Great and Small Game of Europe etc. 1901: 15; The Sheep and Its Cousins 1912: 294; Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 118; McConnell, Ottawa Nat. **6**, 1892: 131.

*Ovis cervina dalli* Elliot, Zool. Publ. Field Mus. **2**, 1901: 47; Zool. Pub. Field Mus. **6**, 1905: 55.

*Ovis dalli*, Allen, Bull. Amer. Mus. Nat. Hist. **9**, 1897: 112; **12**, 1899: 3; Merriam, Proc. Biol. Soc. Wash. **11**, 1897: 217; Hornaday, 5th Rep. N. York Zool. Soc. 1900, (1901):80; Stone and Cram, Amer. Mamm. 1903: 64; Macfarlane, Proc. U. S. Nat. Mus. **28**, 1905: 685; Preble, N. Amer. Fauna No. 27, 1908:127; Osgood, N. Amer. Fauna, No. 30, 1909: 51; Sheldon, Wilderness of the Upper Yukon 1911: 297; Anderson, Rept. Nat. Hist. Coll. in Steffanson, My Life with the Eskimo, 1913: 508; Anthony, Field Book of Mamm. 1928: 545; Hewitt, Conserv. Wild Life in Canada, 1921: 84; Moran, Canada. Field Nat. **42**, 1928: 14.

*Ovis dalli dalli*, Allen, Bull. Amer. Mus. Nat. Hist., **31**, 1912: 27; Miller, Bull. U. S. Nat. Mus. No. 128, 1923: 497; Seton, Lives of Game Animals, **3**, 1927: 577; Laing, Taverner and Anderson, Ann Rept. Nat. Mus. Canada (1927), 1929:105; Dixon, Birds and Mamm. Mt. McKinley Nat. Park, 1938:212.

*Ovis nivicola dalli*, Nassonov, Publ. Russ. Acad. Sci. quoted by Sushkin, Journ. Mamm. **6**, No.3, 1925: 150.

*Type.*—In U. S. National Museum; cotypes named, male number 13266/20786 skin and skull, and female skin only number 13265; mountains south of Fort Yukon on west bank of the Yukon River, Alaska; probably Tanana Hills, winter 1879-80, collected by L. N. McQueston.

*Range.*—Mountains of Alaska, Yukon Territory, North West Territories, west of the Mackenzie River, south in the main chain of the Rockies to the Nahanni River. In northern British Columbia and central Yukon intergrades broadly with *O. d. stonei,* but typical *dalli* is to be found in the St. Elias Range in northwestern British Columbia bordering on the boundary of the Alaska panhandle.

*Measurements.*—Four adult males from the Nahanni River region averaged as follows: Total length 56 inches [1428 mm. (1339-1530)]; tail 4 [102 mm. (89-115)]; hind foot 16 [408 mm. (395-421)]; height at shoulder 37 inches [940 mm. (916-995)]; ear from notch, dry skin 74 mm. (70-76); fore hoof 69 mm. (65-72); hind hoof 66 mm. (63-68). One adult female total length 54 inches (1377 mm.); tail 3½ inches (99 mm.); hind foot 15 inches (383 mm.); a very old ram from the Ogilvie Rockies (Sheldon 1911:340) measured 59 inches from nose to tip of tail and 40 inches at the shoulder; another ram shot by the same author in the Pelley Mountains had identical measurements.

*Weights.*—Seton (1927) states the weights of rams to be about 200 pounds; of ewes 150 pounds. The latter seems too high.

*Color.*—The palest member of the genus, in unstained pelage *O. dalli dalli* is everywhere almost pure white. The horns and hoofs are light amber colored fading after death to a dusty brown; iris yellowish brown.

Though normally white, the short summer pelage in most cases becomes stained soon after it appears and from then until snow time presents a yellowish appearance, the result of staining of the hair by an ochraceous earth.

*Comparisons.*—*O. d. dalli* requires comparison only with *O. d. stonei* the race with adjoining range to the southward. The color of *dalli* is distinctive. Cranially *dalli* differs from *stonei* (males) in average smaller size of all skull measurements taken except mastoid breadth, palatal breadth at $M^3$ and $Pm^2$,

TABLE 5.—Cranial measurements of *Ovis dalli dalli* males.

| *Variate | N | M | R | O | O′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 16 | 249± 1.60 | 235–256 | 6.20 ± 1.09 | 6.40 | 2.48 ± .440 |
| Nasal width | 7 | 91± 2.96 | 85–102 | 7.25 ± 1.94 | 7.85 | 7.97 ±2.13 |
| Nasal length | 7 | 44± 1.35 | 38–46 | 3.25 ± .870 | 3.50 | 7.4 ±1.98 |
| Orbital width | 7 | 112± 1.60 | 108–116 | 3.93 ± 1.05 | 4.25 | 3.50 ± .935 |
| Zygomatic width | 8 | 122± 1.22 | 118–127 | 3.24 ± .810 | 3.46 | 2.65 ± .662 |
| Maxillary width | 17 | 83± 1.01 | 75–90 | 4.05 ± .690 | 4.17 | 4.85 ± .83 |
| Mastoid width | 18 | 89± .724 | 84–96 | 2.99 ± .50 | 3.08 | 3.35 ± .560 |
| Palatal breadth at $M^3$ | 17 | 52± .605 | 48–56 | 2.42 ± .416 | 2.49 | 4.65 ± .80 |
| Palatal br. at $Pm^2$ | 18 | 34± .538 | 28–36 | 2.22 ± .370 | 2.29 | 6.52 ±1.08 |
| Upper molar series | 17 | 76± .762 | 72–82 | 3.05 ± .522 | 3.14 | 4.00 ± .69 |
| Prealveolar length | 17 | 78± .72 | 73–82 | 2.88 ± .495 | 2.96 | 3.70 ± .635 |
| Post dental length | 18 | 87± 1.05 | 81–97 | 4.35 ± .72 | 4.46 | 4.99 ± .83 |

* For explanation of symbols see page 516.

TABLE 6.—Cranial measurements of *Ovis d. dalli* females.

| *Variate | N | M | R | O | O' | V |
|---|---|---|---|---|---|---|
| Basilar length | 4 | 228± 4.05 | 220–238 | 7.03 ± 2.53 | 8.12 | 3.08 ±1.09 |
| Nasal length | 3 | 76± 3.84 | 72–84 | 5.43 ± 2.22 | 6.65 | 7.15 ±2.92 |
| Nasal width | 4 | 33± 1.04 | 31–36 | 1.80 ± .637 | 2.08 | 5.46 ±1.93 |
| Orbital width | 4 | 100± 1.77 | 96–103 | 3.08 ± 1.09 | 3.56 | 3.08 ±1.09 |
| Zygomatic width | 3 | 115± 1.68 | 112–117 | 2.38 ± .965 | 2.92 | 2.05 ± .967 |
| Maxillary width | 4 | 76± 1.8 | 71–79 | 3.12 ± 1.10 | 3.60 | 4.1 ±1.45 |
| Mastoid width | 4 | 78± .706 | 76–79 | 1.23 ± .432 | 1.41 | 1.57 ± .556 |
| Palatal breadth at M3 | 4 | 49± .760 | 48–51 | 1.32 ± 4.65 | 1.52 | 2.60 ± .950 |
| Palatal br. at $Pm^2$ | 4 | 27± .760 | 26–29 | 1.32 ± 4.65 | 1.52 | 4.90 ±1.73 |
| Upper molar series | 4 | 71± 1.52 | 68–74 | 2.65 ± .930 | 3.05 | 3.72 ±1.33 |
| Prealveolar length | 4 | 72± 1.80 | 69–77 | 3.12 ± 1.10 | 3.60 | 4.33 ±1.53 |
| Post dental length | 4 | 86± 3.27 | 82–96 | 5.67 ± 2.0 | 6.55 | 6.55 ±2.30 |

and postpalatal breadth all of which are virtually the same in both races and in consequence relatively larger in *dalli*. Of the measurements differing *dalli* has the basilar length, orbital breadth, prealevolar length and postdental length, maxillary breadth and length of upper molar series significantly less (P in each case less than .01)*

The ratio mastoid breadth to basilar length is significantly greater in *dalli*, 37 per cent (34-40) as against 34 per cent (33-36) in *stonei*.

*Horns.*—In life pale yellow with a semi-transparent appearance; of the typical form for the species (pl. 4). They have been stated by Hornaday (1901:85) to be more closely curled and less flaring than in *stonei*, but this is certainly not the case in the specimens examined by me. The other horn characters assigned to the species by Hornaday (op. cit.) are variable and found in both races of the species indiscriminately.

*Remarks.*—*Ovis dalli dalli* intergrades completely with *O. d. stonei*, the next race to the south with the result that over a wide territory in southern Alaska, the Yukon and northern British Columbia the population is composed in its entirety of all percentages of blood mixtures. The distribution of the species and the details of this intergradation have been thoroughly dealt with by Sheldon (1911). Supplementary information accumulated since his work is slight.

It has long been realized that *Ovis fannini* is a name applied to one of the stages in this intergradation. Skull measurements tend to show that the stages of intergradation from the extreme dark type to and including the "*fannini*" color pattern are clearly referable to *stonei*. The stage in which the sheep is white with a black tail or white with dark tail and scattered dark hairs on the "saddle" have all proven to be cranially referable to *dalli*, many of the intermediate stages in this intergradation cannot be referred to either race.

* P represents the probability that the two samples compared could have been drawn at random from the same variable population. Where the value of P is .01 or less the two compared samples have been regarded as significantly different. Wherever "significant" is used in a comparison it is used with this meaning.

*Specimens examined.*—Total number 114: Unless otherwise indicated are in United States National Museum Biological Survey Collection.†

ALASKA: Near Eagle 2, Mountains south of Fort Yukon 28, Romanzoff Mountains 138, Alaska Yukon boundary 28, Francis Creek, White River 28, Cooks Inlet 48, Chigmi Mountains 28, Savage River 4, Teklanika River 1, 80 miles northwest of Rampart House 2, Mount McKinley 12, Kutuk River 7, Berry Creek 1, Cape Lewis (10 miles south of Cape Lisburn) 1, head of Jennie Creek 2, Kuskokwim River 2, Chitna River 33.2, Hula Hula River, Endicott Mountains 102, head of Nebesna River 36.

YUKON: Yukon Mountains 33, St. Elias Alps, head of White River, Mount Logan 33, *Kluane Lake 1, *MacMillan River, north fork 5, head Coal Creek 4, Cold Creek 1, Head of Donkek River 15, 12 Mile River 42, Klondike River 1.

NORTH WEST TERRITORIES: Rockies at 66 degrees North Latitude 82, Nahanni River above Gates 92.3, Nahanni Mountains 22, South Nahanni River 1, Mackenzie district 13.

### *Ovis dalli kenaiensis* Allen—KENAI SHEEP

*Ovis dalli kenaiensis* Allen, Bull. Amer. Mus. Nat. Hist. **16**, 1902: 145; Miller, Bull. U. S. Nat. Mus. No. 128, 1923: 497; Osgood, N Amer. Fauna, No. 24, 1904:30. Lydekker, Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 119.

*Ovis dalli*, Osgood, N. Amer. Fauna, No. 30, 1909: 51.

*Ovis nivicola kenaiensis*, Nassonov, Publ. Russ. Acad. Sci. quoted by Sushkin, Journ. Mammal **6**, No. 3, 1925:150.

*Type.*—In American Museum of Natural History; male adult number 17609; head of Sheep Creek, Kenai Peninsula, July 10, 1901; Andrew J. Stone collector.

*Range.*—Confined to the Kenai Peninsula, Alaska.

*Color.*—Pure white, as in *dalli*, at some seasons stained from contact with the soil.

*Comparisons.*—A series of nine skulls of adult males from Kenai Peninsula when compared with a series of eighteen adult males from the mainland of Alaska is found to differ in having basilar length less (P = .04), molar series significantly shorter (P less than .01) and basioccipital significantly narrower (P less than .01). In addition, though I was unable to obtain satisfactory measurements of it the angle between the basioccipital axis and the palatal axis is apparently greater as was pointed out by Allen (1902:146). The difference is reflected in the slightly shorter post-dental length of *kenaiensis* though this difference is very much less than was stated by Allen (ibid) and repeated by Lydekker (1913:119). The larger series available to me fails to substantiate the statement by Allen (ibid) that the teeth in *kenaiensis* are broader and heavier and the palate broader. As has already been stated the tooth rows in the peninsula population are shorter. Reference to tables 5 and 8 will illustrate the exact correspondence of the two populations in all measurements of palate and rostrum.

† For key to institutions referred to by index figures see page 541.
* Indicates intergrades between *dalli* and *stonei*.

Females of the two populations as represented by four adults from each area are also readily separable in series.

*O. d. kenaiensis* has the basilar length less (P=.04), is slightly narrower across the orbits, rostrum and zygomata and has the occiput, and post-palate significantly narrower (P in each case less than .01).

*Horns.*—Indistinguishable from those of *dalli*.

*Remarks.*—The presence on the Kenai Peninsula of a population of sheep with characteristics as demonstrably different from those possessed by the sheep of the rest of Alaska seems to me to be of very considerable significance. It probably indicates a very long period of residence there and an effective degree of isolation by the lower ground between the peninsula and the mountains of the contiguous mainland.

Osgood (1904:30) identified a single skull from Lake Clark, at the base

TABLE 7.—Cranial measurements of *O. d. kenaiensis* females.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 4 | 217± .708 | 215–218 | 1.23 ± .432 | 1.42 | .564± .199 |
| Nasal length | 3 | 77± 2.51 | 74–82 | 3.56 ± 1.45 | 4.35 | 5.08 ±2.07 |
| Nasal width | 4 | 32± .352 | 31–32 | .50 ± .202 | .575 | 1.56 ± .638 |
| Orbital width | 4 | 97± 1.89 | 93–102 | 3.28 ± 1.16 | 3.79 | 3.46 ±1.19 |
| Zygomatic width | 4 | 112± 1.87 | 107–115 | 3.24 ± 1.14 | 3.74 | 2.90 ±1.02 |
| Maxillary width | 4 | 74± 1.43 | 70–76 | 2.45 ± .865 | 2.82 | 3.31 ±1.17 |
| Mastoid width | 4 | 72± .865 | 70–74 | 1.50 ± .530 | 1.73 | 2.08 ± .736 |
| Palatal breadth at M3 | 4 | 48± 1.00 | 45–49 | 1.73 ± .610 | 2.00 | 3.60 ±1.27 |
| Palatal br. at Pm2 | 4 | 28± 1.29 | 25–31 | 2.23 ± .787 | 2.58 | 7.96 ±3.53 |
| Upper molar series | 4 | 70± 1.08 | 68–74 | 1.87 ± .663 | 2.16 | 2.68 ± .947 |
| Prealveolar length | 4 | 70± .645 | 69–72 | 1.12 ± .394 | 1.29 | 1.59 ± .562 |
| Post dental length | 4 | 77± .708 | 75–78 | 1.22 ± .432 | 1.42 | 1.59 ± .562 |

* For explanation of symbols see page 516.

TABLE 8.—Cranial measurements of *O. d. kenaiensis* males.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 7 | 243± 1.65 | 237–250 | 4.05 ± 1.08 | 4.37 | 1.67 ± .446 |
| Nasal length | 6 | 88± 1.59 | 83–92 | 3.54 ± 1.04 | 3.88 | 4.00 ±1.16 |
| Nasal width | 9 | 43± 1.04 | 38–48 | 2.95 ± .695 | 3.12 | 6.85 ±1.62 |
| Orbital width | 9 | 112± 1.56 | 119–127 | 4.41 ± 1.04 | 4.67 | 3.94 ± .927 |
| Zygomatic width | 9 | 122± .935 | 119–127 | 2.64 ± .625 | 2.80 | 2.17 ± .512 |
| Maxillary width | 9 | 83± .963 | 78–86 | 2.73 ± .643 | 2.89 | 3.28 ± .775 |
| Mastoid width | 7 | 87± 1.08 | 82–90 | 2.65 ± .71 | 2.86 | 3.04 ± .811 |
| Palatal breadth at M3 | 8 | 51± .864 | 47–54 | 2.29 ± .572 | 2.45 | 4.50 ±1.12 |
| Palatal br. at Pm2 | 9 | 34± .407 | 32–35 | 1.15 ± .272 | 1.22 | 3.40 ± .80 |
| Upper molar series | 9 | 72± .715 | 68–75 | 2.02 ± .478 | 2.15 | 2.81 ± .665 |
| Prealveolar length | 5 | 78± .835 | 75–80 | 1.67 ± .529 | 1.87 | 2.14 ± .675 |
| Post dental length | 5 | 84± .972 | 80–85 | 1.95 ± .615 | 2.18 | 2.32 ± .735 |

of the Alaskan Peninsula as of this race. However my evidence is all to the effect that the population possessing the characteristics described above inhabits only the mountains of the Kenai Peninsula. A series of nine adult rams from Knik River [now Matanuska River?] shows none of the characteristics of *kenaiensis* and differs in no important particular from sheep inhabiting the Alaska mainland.

This series shows not the slightest trace of intergradation with the peninsula population, a testimony to the efficacy of the isolation factors that have operated to foster the development of this race.

*Specimens examined.*—Total number 37*: Skilak Lake, Kenai Peninsula $2^4$, southeastern Alaska $2^4$, Sheep Mountains at head of Sheep Creek, Kenai Peninsula, $19^2$, head of Kussiluf Lake, Kenai Peninsula $3^2$, Kenai Peninsula $4^{8'3}$, Tustemena Lake, Kenai Peninsula $7^8$.

### *Ovis dalli stonei* Allen—Stone Sheep

*Ovis stonei* Allen, Bull. Amer. Mus. Nat. Hist. **9**, 1897: 111, pls. II and III; ibid **12**, 1899: 2; Stone, Bull. Amer. Mus. Nat. Hist. **12**, 1900: 42; Hornaday, 5th Rep. N. York Zool. Soc. (1900), 1901: No. 97; Preble, N. Amer. Fauna No. 27, 1908: 156; Sheldon, Wilderness of Upper Yukon, 1911: 297; Miller, Bull. U. S. Nat. Mus. No. 128, 1923: 497; Moran, Canad. Field. Nat. **42**, 1928: 14; Hewitt, Conserv. Wild Life in Canada, 1921: 81; Anthony, Field Book of Mamm. 1928:545.

*Ovis canadensis fannini*, Lydekker, Great and Small Game of Europe etc. 1901: 19; The Sheep and Its Cousins 1912: 294.

*Ovis canadensis liardensis* Lydekker, Wild Oxen, Sheep and Goats 1898: 215, fig. 41 (Liard River, B.C.)

*Ovis canadensis niger* Millais, The Gun at Home and Abroad, **4**, 1915: 324. (Mountains at head of Skeen River, B.C.)

*Ovis canadensis nigra* Miller, Bull. U. S. Nat. Mus. No. 128, 1923: 496; Seton, Lives of Game Animals **3**, 1927: 577.

*Ovis canadensis stonei*, Lydekker, Wild Oxen, Sheep and Goats, 1898: 217; The Sheep and Its Cousins, 1912: 294; Cat. Ung. Mamm. Brit. Mus. **1**, 1912: 120.

*Ovis cowani* Rothschild, Proc. Zool. Soc. London 1907: 238. (Mountain Chain near Mt. Logan, B. C. [no such mountain is now known in British Columbia. All sheep in the Mt. Logan, Yukon Territory region are white]).

*Ovis dalli fannini* Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912:28; Anthony, Field Book of Mammals 1928: 545; Seton, Lives of Game Animals, **3**, 1927: 577.

*Ovis dalli stonei*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912:28; Seton, (ibid).

*Ovis fannini* Hornaday, prepublished separate from 5th Rep. N. York Zool. Soc. (1900) Jan. 8, 1901: 2; ibid. June, 1901: 78; Osgood, N. Amer. Fauna No. 30, 1909: 51; Moran, Canad. Field Nat., **42**, 1928:14.

*Ovis "fannini,"* Swarth, Journ. Mammal. **17**, No. 4, 405.

*Ovis nivicola cowani*, Nassonov, quoted by Sushkin, Journ. Mammal., **6**, 1925: 150.

*Ovis nivicola fannini*, Nassonov, ibid.

*Ovis nivicola stonei*, Nassonov, ibid.

*Type.*—In American Museum of Natural History, Adult male, Amer. Mus. number 12721: "Che-on-ee Mountains," B. C., headwaters of the Stickeen River near Alaska territory, August 10, 1896. Collected by A. J.

* For key to institutions referred to by index figures see p. 541.

Stone. The Che-on-ee Mountains have never appeared as such on any official map and are unknown to the Geographic Division of the British Columbia Government. According to the location shown on Sheldon's (1911) map the probability is that the type locality lies in what are now the Rainbow Mountains between the Stickine and Iskut rivers. The type was a mounted specimen, since taken down; in consequence the skull lacks the prexamillae and the entire basal and palatal portions. The horns of the type represent the extreme degree of divergence found in the race. In May 1937 the skin of the type had been temporarily mislaid.

*Range.*—The Omineca and Cassiar districts of British Columbia completely north of latitude 56° 30′ west to the summit of the coast range and Lake Atlin, east to the Rocky Mountains, south to the Peace River along the slopes bordering the Nabesche River, Ingenika Range (Haworth 1917:129), Klappan Range; north in the Cassiar Mountains and adjacent ranges at least as far as the Pelley River but in the northern Cassiar and Pelley Mountains blending into *dalli*. In so far as can be discovered the range of *stonei* neither now nor formerly made contact with that of *canadensis*.

*Diagnosis.*—A dark brown almost black, sheep with underparts and face white, neck grizzled. Skull larger and heavier than *dalli;* horns darker than *dalli* but not otherwise distinguished.

*Measurements.*—Four adult males from Iskut River and Tuchodi Lake have the following average and extreme measurements: Total length 64 inches, 1605 mm. (1300-1780); tail 4 inches, 102 mm. (75-109); hind foot 17 inches, 436 mm. (412-450); fore hoofs 73 mm. (70-76); hind hoof 65 mm. (62-68); ear from notch (dry) 75 mm. (62-85). Measurements of an adult female (Hornaday 1901:98). Total length 52 in. (1324 mm.); tail 3 in. (77 mm.); hind foot 15 in. (382 mm.); height at shoulders 32½ in. (814 mm.).

*Horns.*—Extremely variable as to shape but the majority are wide spreading, with heavy, overlapping outer ridge, and rugose bases, tips entire and always recurved. In color light brownish, much as in *Ovis canadensis*. As to measure-

TABLE 9.—Cranial Measurements of *O. d. stonei* males.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 10 | 262 ± 2.2 | 248–274 | 6.62 ± 1.48 | 7.0 | 2.52 ± .564 |
| Nasal length | 10 | 96 ± 2.81 | 82–110 | 8.45 ± 1.89 | 8.92 | 8.80 ±1.97 |
| Nasal width | 12 | 46 ± .935 | 42–51 | 3.11 ± .634 | 3.25 | 6.72 ±1.38 |
| Orbital width | 13 | 120 ± 1.46 | 109–125 | 5.06 ± .995 | 5.27 | 4.22 ± .830 |
| Zygomatic width | 13 | 125 ± 2.00 | 114–134 | 6.92 ± 1.36 | 7.20 | 5.54 ±1.09 |
| Maxillary width | 13 | 88 ± 1.57 | 80–103 | 5.45 ± 1.07 | 5.65 | 6.18 ±1.22 |
| Mastoid width | 12 | 90 ± 1.16 | 82–97 | 3.84 ± .785 | 4.00 | 4.28 ± .875 |
| Palatal breadth at M3 | 10 | 54 ± 1.00 | 49–58 | 3.00 ± .670 | 3.16 | 5.55 ±1.24 |
| Palatal br. at Pm2 | 9 | 33 ± .87 | 28–33 | 2.47 ± .584 | 2.62 | 7.48 ±1.77 |
| Upper molar series | 11 | 81 ± 1.49 | 72–88 | 4.71 ± 1.01 | 4.94 | 5.81 ±1.24 |
| Prealveolar length | 11 | 83 ± .948 | 78–90 | 3.00 ± .640 | 3.14 | 3.60 ± .770 |
| Post dental length | 10 | 92 ± .92 | 86–98 | 2.92 ± .621 | 3.07 | 3.16 ± .676 |

* For explanation of symbols see page 516.

ments the record head, taken in 1936, on the Muskwa River, B. C., by L. S. Chadwick of Cleveland, Ohio, measures 51⅝ inches in length round the curl, basal diameter 15⅛ inch; tip to tip 31 inches. Nine adult males from 5 years to 10 years and averaging approximately 8 years old, have the following dimensions. Basal circumference 13 in., 321 mm. (294-348); right horn around curve 32½ in., 816 mm. (670-970); tip to tip 25 inches, 620 mm. (575-690).

*Color.*—Extremely variable; in the darkest adult males the general body color ranges from between Seal or Bone Brown and Blackish Brown, darkest on the dorsal line from crown to tail tip, flank line where dark of upperparts meets white of underparts and outsides of fore and hind legs. Face in darkest individuals dirty white, darkening on cheeks, throat and neck; axilla and band across chest dark, sides of body paler, underparts insides of fore and hind legs and rump patch white, the latter divided dorsally by dark line from back to tail. Ears, inside white, outside gray. In paler individuals the face and neck becomes progressively lighter through the increasing preponderance of white hairs until these areas are almost white, at the same time white hairs encroach on the flanks until in the lightest specimens the dark body color is confined to a saddle patch extending down each side, to the dorsal line, including the tail, and the outsides of the fore and hind limbs. These dark patches are lightened also by the presence of many white hairs.

In two large series from single localities the ewes are consistently lighter in color than the rams except for the dark mid-dorsal line and dark tail.

*Lamb.*—Variable but always lighter than corresponding adults. Two October individuals from Iskut Summit, B. C., are largely whitish, the dorsal line, tail, tail stripe, outsides of legs, and flanks are grayish, the axillae somewhat darker. Another lamb seen was much darker—almost indistinguishable from *Ovis canadensis*.

*Comparisons.*—*Ovis d. stonei* need be compared only with *dalli*, which see.

*Specimens examined.*—Total number 100:*

BRITISH COLUMBIA: Walker Creek, Dease River 41; Laurier Pass 51.8.2; Liard River1; Klappan River 31; East of Turnagain River 21; Cassiar Mountains ‡31.6; Cassiar Pass 11; Keilly Creek 18; Sikanni Chief River 18; Prophet River 38.7; Ottertail River 18; Halfway River 16; Stikine River 128; Iskoot Summit 62; Shesley Mountains 22; Headwaters of Stikine River 42; Tuchadi Lake 42; between Prophet and Musqua River 12; Nakinaw River, Atlin district 57; Telegraph Creek 17; Forty Mile Creek 27.

YUKON: ‡Tow-we-oh, Teslin Area 13; ‡Teslin Lake 83; ‡Snowden Mountain 143; ‡head of Morley River 53; Dawson 22.7; Caribou Crossing 13; ‡Klondike River 11; ‡Pelley River 11.

### *Ovis canadensis canadensis* Shaw—CANADA BIGHORN

*Ovis canadensis* Shaw, Naturalists Miscellany XV, Pl. DCX with text about Dec. 1803 [Mearns 1907: 235]; Biddulph, Proc. Zool. Soc. London, 1885: 678-684; Merriam N. Amer. Fauna, No. 3, 1890: 78; N. Amer. Fauna, No. 5, 1891: 81;

‡ Indicates intergrades between *dalli* and *stonei*.
* For a key to institutions referred to by index figures see p. 541.

Preble, N. Amer. Fauna, No. 27, 1908: 155; Warren, Mamm. of Colorado, 1910: 9; Carey, N. Amer. Fauna, No. 33, 1911: 62; Millais, The Gun at Home and Abroad, **4**, 1911: 323; Osgood, Proc. Biol. Soc. Wash. **26**, 1913: 80; **27**, 1914: 13; Hewett, Conserv. of Wild Life in Canada, 1921: 78; Brooks, Canad. Field Nat., **37**, 1923: 23; Moran, Canad. Field Nat. **42**, 1928: 12.

*Ovis canadensis canadensis* Miller, List Mamm. U. S. Nat. Mus. 1912: 395; Hollister, Canad. Alpine Club Journ., 1912: 40; Lydekker, Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 111; Seton, Lives of Game Animals, **3**, 1927: 522; Barnes, Bull. Univ. Utah, **17**, No. 12, 1927: 175; Anthony, Field Book of Mammals, 1928: 544; Bailey, N. Amer. Fauna, No. 53: 16; Anderson Canad. Yearbook, 1937: 41; Davis, Journ. Mammal. **19**, No. 1, 1938: 88.

*Ovis canadensis typica* Lydekker, Wild Oxen, Sheep and Goats, 1898: 209, pl. xvii; Great and Small Game of Europe, etc., 1901: 10;

*Ovis cervina* Desmarest, Nouv. Dict. Hist. Natur. XXIV, 1804: 5; Rafinesque, Amer. Monthly Mag. **1**, 1817: 436; Allen, Bull. Amer. Mus. Nat. Hist. **7**, 1895:258.

*Ovis cervina cervina*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 23.

*Ovis montana*, Cuvier, Regne Anim. **1**, 1817: 267; Wied, Reise in das Innere Nord Amerika. . . . , 1839-41: Baird, Rept. R. R. Surv. and Exp. **8**, 1857: 678 (part); Wied, Verz. der auf Seiner Reise in Nord Amerika beob. Säugethiere, 1862:225-230. pl. 4. Coues and Yarrow, Rept. Wheeler Surv. *V*, Zoology, 1875: 68; Russell, Expl. in the Far North, 1898: 236; Hornaday, Fifth Ann. Rept. N. Y. Zool. Soc. (1900), 1901: 101.

*Ovis ammon* Mitchell, "New York Medic. Repos., *X*, 1807: 35; Ord. in Guthries Geography (2nd Am. Ed., **11**, 1815: 292, 208)"; Harlan, F. Americana, 1925:164.

"*Ovis pygargus* Hamilton Smith, Griffith's Cuvier, *IV*, 1827: 318, pl; *V*, 1827: 359."

*Range.*—In Canada confined to the Rocky Mountains in which it ranges north to the vicinity of Wapiti Pass some one hundred and twenty miles south of the Peace River; south through western Montana, eastern Idaho, Wyoming, Utah and into Colorado.

*Diagnosis.*—A large dark brown sheep with heavy horns tapering very gradually to (in older rams) blunt points. Skull of males longer and relatively narrower with narrower palate than any other race, short tooth row and very long post-palatal segment.

*Measurements.*—A fully adult ram (6 years old) from Wiggins Fork, Colorado, measures as follows: Total length 6 feet, 5 inches (1953 mm.); tail 5 inches (127 mm.); hind foot 15½ inches (394 mm.); ear from notch measured in dry skin, 63 mm.; fore hoof 77 mm.; hind hoof 63 mm.

Another adult ram from Maligne Lake, Alberta, measured, length 1600 mm.; tail 100 mm., hind foot 440 mm., ear from notch, measured on dry skin 100 mm., fore hoof 82 mm., hind hoof 74 mm.

A five year old ram from Glacier County, Montana, measures correspondingly: 1726-95-482-127.

An adult female from Glacier County, Montana, measures 1490-80-420-112; a five year old ewe from the same place 1433-121-406-121. For cranial measurements see pages 516 and 517.

A ewe from Eleanor Creek, Wind River Mountains, Wyoming, measures: Total length 4 feet 6 inches (1369 mm.); tail 4¾ inches (120 mm.); hind foot 15½ inches (394 mm.); ear in the flesh from crown 5 inches (127 mm.).

*Weights.*—Three rams taken by Phillips (Hornaday 1906) in Kootenay district of British Columbia weighed as follows: a thirteen year old 316 pounds; a ten year old, 285 pounds; and a five year old 287 pounds. Audubon (Q.N.Amer.1851) cites a weight for an adult ram of 344 pounds. A two year old weighed 110 pounds and a three year old (idem.) 170 pounds. A full grown ewe from Wyoming weighed 136 pounds, a two year old ewe from the same place 103½ pounds (Seton 1927).

*Horns.*—Characterized in the usual form by very flat spiral; heavy bases tapering slowly so that circumference 12 inches from base is very little less than basal circumference; horn tips of old rams usually broken. Front surface of horn relatively (to *dalli*) smooth and without prominent lateral ridges. Average horn measurements of seven rams from the Rocky Mountains of southern British Columbia and Alberta with an average age of a little over eight years are: Basal circumference 15 inches (373 mm.); length of right horn outside curve 34 inches, (857 mm.); tip to tip 18 inches (449 mm.).

*Color.*—Extremely variable even in the same band. An adult male from Maligne Lake, Jasper Park, Alberta, represents an average coloration. It is as follows: Dorsal coloration between Avellaneous and Wood Brown becoming darker on neck, sides, chest ventrally and on legs and tail; mid-dorsal line inconspicuous but continuing onto tail thus completely dividing the rump patch dorsally; yellowish patch on brow; face Natal Brown, sides of face grayer, nose whitish, ears grayish, white inside; rump patch yellowish white; belly whitish. Darkest color found in *canadensis* is about Natal Brown to Mars Brown over the dorsal surface. Amount of white on underparts variable, usually confined to inguinal region but sometimes extending forward onto chest. Ewes same color as rams. Color described is for fresh winter pelage, fading during the winter changes the color to a brownish drab by spring.

A young lamb from Banff, Alberta, has the dorsal surface Light Drab, tail about Wood Brown; lower parts of front legs between Wood Brown and Bister; hind legs more or less drab throughout; nose whitish, ears drab, white inside.

*Comparisons.*—*O. c. canadensis* differs from *mexicana* and *nelsoni* in larger size, actually and relatively darker with consequent sharper contrast between dark and light areas; the nose is markedly lighter than the face in *canadensis*, differentiated slightly or not at all in *mexicana*, dark line from rump to tail strong and always present rather than frequently discontinuous.

The existing material representing *auduboni* does not permit of detailed external comparisons between these two races.

*Cranial Comparisons.*—The series of nine female *canadensis* differs from the series of six female *mexicana* from southwestern Arizona and adjoining mountain ranges in northern Sonora Province, Mexico in being generally

larger in all cranial features measured except the maxillary width which is the same in both series and the palatal width at $m^3$ and the length of the upper molar series in which *canadensis* is slightly the smaller. However the differences are for the most part not significant with such small series. The following measurements on the other hand prove to be significantly greater in *canadensis:* mastoid width, post-dental length, width of basioccipital and post-palatal width. In all these the value of P is less than .01.

Comparison of males of these two races reveals that *canadensis* averages slightly larger than *mexicana* except in maxillary width, width of palate at $M^3$ and length of upper tooth row in which the inverse relation is true. The males of the northern race exceed in length of skull those of the southern race to a greater degree than do the corresponding females (see tables 2, 3, 12 and 13). Thus the basilar length is significantly greately in *canadensis* males as also is the prealveolar length, post-dental length, orbital breadth and the mastoid breadth, P in each case being less than 0.1. The mean nasal length of *canadensis* is greater by 5 mm. than that of *mexicana* but as this is a highly variable feature the value of P is but 0.4 and throws doubt on the significance of this difference. The apparently narrower maxillary area and shorter molar rows each have a value of P of .1 or slightly greater and cannot be said to have significance on the available data.

As regards cranial proportions the rostrum is relatively narrower in *canadensis* in which the mean of the ratio between maxillary breadth and basilar length is 33% (30-34) rather than 36% (35-38). The upper tooth row also occupies a relatively smaller part of the basilar area of the skull thus the mean ratio of length of upper tooth row: basilar length is 30% (28-32) in *canadensis*, 34% (32-35) in *mexicana*. In each of these instances the value of P is considerably less than .01 and the differences can be considered significant.

Females of *canadensis* have the skulls much the same as those of *mexicana* in basilar length, the nasals also, though slightly longer in the series of *canadensis* examined are not significantly so.

However the nasals are significantly narrower, zygomatic width greater, maxillary width less and postpalatal width greater (P in each case less than .01) than in *mexicana* females. In addition the upper molar row averages shorter and though the value of P is a little less than .05 this difference will probably prove significant when larger series become available. Similarly the mean post-dental length is 7 mm. greater in *canadensis* and though the value of P is but .03 the difference may prove to be significant under similar condition.

The males of *mexicana* differ more widely from those of the northern race *canadensis* than do the corresponding females.

The small series of adult female *nelsoni* from the Grapevine Mountains and adjacent ranges in Nevada and California differ from the series of female *canadensis* in being smaller in all twenty-two cranial measurements taken save length of molar rows, basal circumference of horns, and spread of horns, in which they slightly exceed corresponding means for the latter race. Basilar length, orbital width, zygomatic width, and mastoid width are all significantly

greater in *canadensis* females and the following dimensions though yielding in a comparison of the two races values of P greater than my chosen point of critical significance, may prove to indicate real differences when larger series are available: nasal length (P greater than .05), nasal width (P=.03), width of palate at $Pm^2$ (P less than .05), length of upper tooth row (P greater than .1).

As regards proportional differences in female skulls of these two races, *canadensis* has the tooth row significantly shorter, ratio length of tooth row to basilar length 33 per cent (31-35) as against 36 per cent (34-37); and has the rostrum relatively narrower as reflected in the ratio of maxillary width to basilar length and width of palate at $M^3$ to basilar length. These ratios are respectively, 33 per cent (30-36) as against 36 per cent (34-37) and 21 per cent (20-22) opposed to 23 per cent (22-24) in *nelsoni*. In each instance the value of P is .01 or less.

Skulls of males of these two races differ somewhat similarly. *Canadensis* is larger in all measurements taken save nasal length, nasal width, maxillary breadth and length of upper molar series in which means for the two races are about identical. Basilar length, orbital width, mastoid width, width of palate at $Pm^3$, prealveolar length and postdental length are all significantly greater in *canadensis*, (P less than .01).

As in the females the upper tooth row is relatively shorter in male *canadensis* than in male *nelsoni*, ratio length of upper molar series to basilar length 30 per cent (28-32) rather than 33 per cent (29-36). The ratio of the mean maxillary breadth to basilar length in males of *canadensis* and *nelsoni* are the same as in the females 33 per cent (30-34) in the former, 36 per cent (33-40) in the latter. These proportional differences are both significant. In addition the nasals, having the same dimensions in both races, are relatively larger in *nelsoni* but the highly variable nature of these bones renders this difference of little value when individual specimens are being considered.

The differences between females of *canadensis* and *californiana* as represented in material available to me are few and slight. *Canadensis* averages a little larger in all measurements except maxillary width, and length of upper tooth row, which are slightly smaller, and nasals and palatal width at $Pm^2$ which are amost identical in the two races. Only the length of the post-dental area is significantly greater in *canadensis*.

In *canadensis* that part of the skull anterior to the tooth rows when compared with the post-dental length is relatively greater than it is in *californiana*. The post-dental length averages 98 per cent (94-107) of the prealveolar length in the latter, 107 per cent (95-119) in the former. The value of P for these ratios is 0.3.

Males of the two races display greater differences from each other than do females.

Males of *canadensis* have the skulls averaging larger than *californiana* in all measured features but maxillary width and length of tooth row, which are smaller, and nasal length and width, width of palate at $M^3$, width of basioc-

cipital, orbital width and zygomatic width which are the same or essentially the same in both.

The following features are significantly different: basilar length, mastoid width and post-dental length, all are greater in *canadensis*. In addition comparison of the means for the prealveolar length, discloses a difference of 7 mm. in favor of *canadensis*. Value of P is .02 so that this difference is possibly significant.

The tooth row is relatively (to the basilar length) longer in *californiana*, this ratio being 33 per cent (30-35) as against 30 per cent (28-32) in *canadensis*. The rostrum is significantly broader, ratio of maxillary breadth to basilar length 35 per cent (32-37) rather than 33 per cent (30-34).

For comparison of *canadensis* with *auduboni* see discussion of the latter race.

*Status*.—British Columbia: The Rocky Mountain bighorn remains abundant in almost all of its former range. It is found native only in the Rocky Mountains and has not within recent time occurred in the adjoining Selkirk Range. In the Rocky Mountains it is found north approximately to the 55th parallel of north latitude though its range in British Columbia is discontinuous. In this province sheep from Banff were liberated at Spences Bridge in the Cascade Mountains in 1927, Lloyd (1927:140) at Squilax in 1926 and at Squam Bay in the Adams Lake region some years later. They have established themselves in all these areas.

Alberta.—The bighorn is abundant and fairly evenly distributed in the Rocky Mountains from the southern boundary north as far as those mountains extend in the province.

Montana.—Wright and Thompson (1935:73) quote the United States National Park 1933 census of 313 bighorn in Glacier National Park. The 1938 Game Census of the Bureau of Biological Survey estimates the bighorn population of this state at 1126 individuals. I have been able to obtain little precise information as to location of bands and numbers included in each but Mr. J. A. Weaver, State Fish and Game Warden, writes me under date of November 22, 1939, that there is "a nice band in the Gallatin Range, in Gallatin County, several on the Flathead, Sun River, and a small bunch in the Benchmark Country in northern Lewis and Clark counties." He further states that the largest band is near Hamilton, in Ravalli County.

Colorado.—The 1938 Big Game Census already referred to places the sheep population of Colorado at 2150 head. Here again I have been unable to obtain any information on the disposition of this population within the State. It is reliably reported that there is at least one large band in the mountains adjacent to Ouray, and another in Rocky Mountain Park.

A letter received by Dr. C. Hart Merriam from Dall Weese, Canyon City, Colorado, February 8, 1898, summarizes the conditions then existing as follows: "I think I know every bunch of bighorn sheep in Colorado and will here give you their ranges. On Cooper Mountain (20 miles from Canyon City) about

fifteen to twenty sheep; on Cochetope Mountains (West of Saquache) sixty to eighty; on Red and Elk Mountains (about Ouray) two hundred to three hundred; on or near Shingle Peak (north of Glenwood Spring) thirty to forty; on Wah Mountain (40 miles from Canyon City) twenty to thirty; on Medicine Bow, Front, and Snowy Range (west of Denver) one hundred to two hundred; on Roan Creek, Book Cliffs (north of Grand Junction) forty to fifty. . . . I have seen some of these sheep in all these different localities."

Wyoming.—A map in possession of Dr. C. Hart Merriam, prepared by Frank Bond shows the areas in Wyoming known to be inhabited by sheep in 1887. This map shows bands of sheep in the Shoshone Mountains, Shoshone Range, Wind River Mountains about as far south as 42° 40′ and extending easterly into the western end of the Owl Creek Mountains. Another band was known to exist in the Rattlesnake Mountains, still others in the Sierra Madre on the southern boundary in the Medicine Bow Mountains, in the whole length of the Laramie Mountains, from the North Platte River south to 41° 30′, in the mountains on the east side of the North Platte north almost to the 43rd Parallel, and in the Grand Tetons and Snake River Range.

In a letter dated April 4, 1939, O. J. Murie of Jackson, Wyoming, summarizes the present distribution of bighorn in that state as known to him. He states "There are some in Yellowstone Park, which winter largely at the north side. There is a herd in the mountains of the Gros Ventre River drainage, south of the Park, and another in the Upper Yellowstone, Thoroughfare region. A few sheep are found in the Hoback area just south of Jackson Hole and some on the headwaters of Granite Creek, which flows into the Hoback. Other sheep are found in the Wind River Range, which extends out on the plains east of Green River. From there northward are mountain sheep at intervals up into the Absoroka Mountains. . . . There are a very few in the Teton Mountains. A few years ago about twenty were introduced in the Bighorn Range, farther east, but I am not sure at this time whether they survived."

Nevada.—Borell and Ellis (1934:43) record the presence of sheep in the Ruby Mountains of northeastern Nevada as lately as 1921. None have been seen there since that year. The race involved is doubtful. A large set of horns from the Owhee Mountains on the Idaho-Nevada boundary as mentioned below apparently indicate in that area a stock presenting characteristics intermediate between *canadensis* and *nelsoni*. A single horn sheath from Baker Creek, White Pine County, is abnormal and gives no hint of the characteristics of the sheep formerly inhabiting that range. The same is true of a fragmentary skull from the Shell Creek Range, White Pine County (see *nelsoni*).

Idaho.—W. B. Davis of Bryan, Texas, under date of October 9, 1937, writes me as follows: "Owyhee County: In May, 1935, I saw the mounted horns of a mountain sheep at Grand View (Owyhee Co.) that had been found in the mountains near Silver City a few years (3 or 4) before. No bighorn occur in southwestern Idaho to-day. They have been exterminated by sheep herders and the severe competition of domestic sheep. Blaine County: Copper Creek, six miles north of Muldoon, (horn sheath only examined). Bannock County: a weathered horn examined from Minx Creek, eleven miles southeast

of Pocatello. . . . Dr. Fayne Kenagy of Rupert, Idaho, reported several sheep on Upper Loon Creek, Custer County. I have seen, or had told me by reliable people that sheep occur in the Pahsimeroi Mountains; Custer County, a small flock reported by a local rancher. A few sheep are in the Sawtooth Mountains above Stanley Lake (reported by several persons independently) in Custer County. The State Fish and Game Department (Cokert, 1935, in 21st Amer. Game Confer. Rept.) estimate 2000 sheep occur in Idaho. Most of them are along the Salmon River, and the South and Middle forks of the same; that is the east central portion of the state. I know of no records for northern Idaho above Clearwater County. I should say the total state population is entirely restricted to that relatively inaccessible mountainous east central part of the state from Hailey north to near Elk City and from Payette Lake east to the Montana Line." A skull from the Owyhee Mountains measured by C. Hart Merriam had basal circumference of 14¼ and 14¾ inches and measured 14 inches in circumference fully half way to the tips. This character almost certainly indicates *canadensis*, however the wide spread, 26½ inches shows gradation toward the *nelsoni* type.

As recently as December, 1920, R. W. Limbert, taxidermist of Boise, Idaho, wrote to Dr. Merriam that he had seen a band of about 18 sheep on the lower part of Battle Creek and Deep Creek in Owyhee County.

Washington.—The sheep formerly occurring in the Blue Mountain region of southeastern Washington supposedly belong to this race. No identifiable material is available and in all probability the exact status of the bighorn of this area will remain forever a mystery.

A pick-up skull of an old male from Upper Tucannon River, Columbia County, in possession of the United States Forest Service at Olympia, Washington, is so badly broken as to present few characters of diagnostic worth. However the orbital width, and mastoid breadth while just within the maximum shown by my series of *californiana* are closer to the average and well within the maximum of *canadensis*. The breadth of the palate between $Pm^2$ of this specimen is greater than in any specimen of *californiana* measured and only just within the maximum of *canadensis*.

Therefore pending the securing of more adequate material and acknowledging the inadvisability of attempted racial allocation of single individuals from marignal localities it seems best to refer the sheep formerly inhabiting the Blue Mountains of southeastern Washington to the race *canadensis*.

Oregon.—Approximately fifty individuals are reported (United States Forest Service Game Census 1933) to inhabit the Wallowa Mountains south east of Joseph, Oregon, on upper Sheep Creek. From the examination of a skin and fragmentary skull Bailey (1936:63) suggests that this population represents the race *canadensis;* until better material is available this must remain doubtful.

A circular released by the Bureau of Biological Survey on October 19, 1939, announces the liberation of twenty-three bighorn from Montana on the Hart Mountain Antelope Refuge, Klamath Falls, Oregon.

New Mexico.—The bighorn of the Rocky Mountains at one time ranged into northern New Mexico along the Sangre de Cristo Mountains as far south as Truchas Peaks, Pecos Baldy and Santa FeBaldy on the east of the Rio Grand Valley, and probably through the San Juan Mountains to Jemez on the west of the valley. There are few if any left in these regions at the present time. (Bailey 1931:16.)

J. Stokely Ligon, Bureau of Biological Survey, Albuquerque, writes (in litt. May 27, 1939) that some years ago the State Game Department received a few head from Canada. They were released in the Sangre de Cristo Range northeast of Sante Fe.

Utah.—Barnes, writing in 1922 on the distribution of sheep in this state reports their probable presence at that date on Escalente Creek, Garfield County, Grand River, Grand County, Zion Canyon near Springdale, Washington County, about four hundred head in the Ashley Forest a few on Mount Timpanogos near Porovo, on Granite Mountain, Tooele County, in the canyons of the Grand and Colorado rivers and upwards of one hundred and fifty head in the Uinta Mountains. He quotes Professor Marcus E. Jones as having seen sheep near Kanab, Kane County, along the Grand River, near Castle Dale and on the Frisco Mountains, Beaver County.

N. B. Cook, Utah Fish and Game Commissioner, writing under date of May 4, 1939, states that "all the sheep remaining within the borders of the state are to be found on the rugged edges of the Green and Colorado rivers. The estimated number of these sheep in the entire state is less than three hundred. We also have one authentic report of a small band on the Wasatch Forest on the Uintah slopes below Mount Baldy."

In further elaboration of the present distribution of sheep in Utah Clifford Presnall, Acting Chief, Wildlife Division, Branch of Research and Information of the United States National Park Service, writes under date of April 13, 1939.

> Small bands of bighorn still exist at widely separate points in the canyons of the Colorado River and its tributaries north of the Grand Canyon. Herds of which I have personal knowledge are:
>
> 1. Zion National Park, just above the junction of the Virgin River and the north fork of the Virgin River; about 25 head apparently slowly increasing in numbers after near extermination in 1930.
>
> 2. A few individuals in the Virgin River Canyon approximately on the Utah-Arizona Line. The present status of these is not known.... but six or eight years ago two or three were seen there. Two or three small bands, perhaps fifteen to fifty in a band, in the Colorado River canyons between the Utah-Arizona Line and a point some fifty miles north.
>
> 3. A small band on the Green River a short distance above its junction with the Colorado.
>
> It is evident that sheep formerly occurred in most of the mountains of the state. They have now reached perhaps the lowest ebb in the history of the state and it is doubtful that they will survive except where they are protected from the competition of domestic sheep and from the constant drain of poaching.

The only specimens I have examined from the state or closely adjoining territory are six from the Green River near the mouth of the Yampa River and one from Grand County, thirty-five miles north of Green River P. O., Utah. In cranial length two adult males of this series are well within the range of variation for *canadensis* and larger than the largest measured skulls of *mexicana* and *nelsoni*, they resemble *canadensis* also in maxillary width and in length of upper molar series but in the small size of the nasals, they show some approach toward *mexicana*. The horns are more slender than in either *mexicana* or *canadensis* which may or may not be a tendency toward *nelsoni*. The single adult female skull similarly shows almost complete agreement with *canadensis*, the sole point of difference being in the reduced size of the nasals.

Grand Canyon specimens from northern Arizona are discussed in the treatment of *nelsoni*.

*Specimens examined*.—Total number 143.*

ALBERTA: Hillsdale 21, Sulphur River 11, 15 miles south of Henry House 11, southeast of Mount Brazeau 11, Henry House 31, Smoky River 41, Brazeau Glacier 11; Thoral Creek, 50 miles northeast of Jasper 12, Maligne Lake 38, Johnson Creek 18, Banff 58.1, Horn Creek 18, Sawback Range 38.1, Johnson Creek 28, Red Deer River 18, Upper Brazeau 36, Waterton Lakes Park 93, near Banff 64.

BRITISH COLUMBIA: Cross River 11, Whitewater Lake 31, Wapiti River 1, Sheep Creek 41, head of Kootenay River, 35 miles southwest of Banff 51, Mount Quintette on Kiskatenaw River 11, Rocky Mountains east of Cranbrook 27, Jarvis Pass 38, Fording River 36.

WYOMING: Unstated 11, Carter Mountains 11, Crowheart Mountains 31, Needle Mountain 11, near Riverton 15, Dinwoody Mountains, Fremont Co. 15, Percy, Carbon Co. 18, Shoshone Mountains 28, Gardiner, Yellowstone Park 14.

COLORADO: Rawah Peak, Medicine Bow Range 31, Arapohoe National Forest 11, Elk Creek, Cochetopa National Forest 11, Holy Cross National Forest 11, 3 miles northeast of Almont 14, Jefferson 21, Kenosha Range 11, Rocky Mountains 11, Wiggins Fork 12, Denver Mountain Park 12, Twin Lake 38, Delta Co. 18, Yellowstone Park 18, Ladore Canyon, Green River, 4 miles above mouth of Yampa River 36, Junction of Yampa and Green rivers 36.

IDAHO: Borgamin Creek, tributary to Salmon River, 50 miles south of Grangeville 11, Bruneau 11, Meadow Creek 11, Wind River 11, Salmon City 12, 11 miles southeast of Pocatello, Bannock Co. 14, Copper Creek, Muldoon 14.

UTAH: Uinta Mountains 11, Mouth of Florence Canyon, 35 miles north of Green River 16.

MONTANA: Bitterroot National Forest 21, Crow Creek 21, Helena National Forest 11, Lewis and Clark Forest 31, Babb Mountain 12, Three Buttes 28, Many Glacier 134, 4 miles north of Warland on Kootenai River 14.

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* In all specimens examined lists the following index numbers refer to the institutions indicated. 1=United States National Museum, Biological Survey Collection; 2=American Museum of Natural History; 3=National Museum of Canada; 4=Museum of Vertebrate Zoology; 5=Field Museum of Natural History; 6=Carnegie Museum; 7=British Columbia Provincial Museum; 8=United States National Museum; 9=Philadelphia Academy of Sciences; 10=California Academy of Sciences; 11=University of Kansas Museum of Zoology.

### *Ovis canadensis auduboni* Merriam—Audubon Bighorn

*Ovis canadensis auduboni* Merriam, Proc. Biol. Soc. Wash. **14**, 1901: 31; Lyon & Osgood, U. S. Nat. Mus. Bull. **62**, 1909: 10; Lydekker, The Sheep and Its Cousins, 1912: 289; Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 113; Millais, The Gun at Home and Abroad, **4**, 1915: 323; Miller, Bull. U. S. Nat. Mus. **128**, 1923: 495; Seton, Lives, **3**, 1927: 522; Grinnell, Journ. Mammal. **9**, No. 1, 1928: 1; Anthony, Field Book of Mamm. 1928: 544.

*Ovis cervina auduboni*, Elliot, Zool. Publ. Field Mus. **2**, Supl. 1901: 484; Zool. Publ. Field Mus. **6**, 1905: 53; Stone and Cram, Amer. Mamm. 1903: 64; Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 26.

*Ovis montana*, Baird, U. S. Pac. R. R. Exp. & Surv. **8**, 1857: 679 (part).

*Type.*—In United States National Museum: Young male, U.S.N.M. Number 22610, skull only "upper Missouri." Probably collected in the badlands of South Dakota in 1855 by Dr. F. V. Hayden.

*Range.*—Now extinct but thought formerly to have occupied the badlands adjoining the Missouri River in North and South Dakota, extreme western Nebraska, and probably into eastern Wyoming.

*Diagnosis.*—Probably somewhat paler than *O. c. canadensis*. Upper tooth row averaging longer and tooth rows less nearly parallel than in that race.

*Measurements.*—Not known, probably much the same as in *O. c. canadensis*.

*Horns.*—Not distinguishable from the spreading type of *canadensis*.

*Color.*—A sub adult female, American Museum of Natural History Number 14516 from Mandan, North Dakota, in fall pelage is somewhat lighter than *canadensis* in corresponding pelage. The dorsal surfaces approach Vinaceous-Buff, darkening on the legs. Underparts, tip of nose and lower jaw white.

A juvenile male from the same locality is darker, the dorsal surface Wood brown, face pale brownish white, underparts and inside of legs white. Tail stripe not complete across rump patch.

*Cranial Comparisons.*—As the range of *auduboni* so far as we know abutted only upon the range of *canadensis* it is necessary to make comparison only with that race.

Females of the two races prove to be significantly different in nasal width, maxillary width and possibly in mastoid breadth ($P = .04$). In each *auduboni* is larger than *canadensis*.

The males on the other hand are significantly different only in width of the basioccipital in which *canadensis* exceeds *auduboni* and possibly also in length of upper tooth row ($P = .04$).

Means of the two female individuals in all the cranial measurements taken are essentially the same as those of *canadensis* except width of nasals, maxillary width and width of mastoid area as already mentioned. Length of molar series and width of basioccipital are from inspection much the same in both races

but data for these is given for purpose of comparison with the situation in the males.

In calculating the value of P for the maxillary width rather than use the very small coefficient of variability displayed by the two specimens of *auduboni* available I assumed a coefficient the same as that demonstrated for *canadensis* and from it derived a standard deviation which was used in determining the probability of significance.

A similar procedure was utilized in determining the value of P in the comparison of basioccipital width in males of the two races.

I did not find the depth of the lower mandible from dental rim to lower margin in *auduboni* to be significantly different from the condition in *O. c. canadensis* as suggested by Merriam (1901:31) however were a greater number of specimens available it might be possible to establish such a difference.

*Remarks.*—*O. c. auduboni* based as it is on slight cranial characters presented by a small number of specimens is to be regarded as a weak race. The indications are however that the characteristics exhibited by these individuals are not the result of chance and that sheep so characterized inhabited a definite range in the badlands to the east of the Rocky Mountains. The absence of identifiable material from eastern Wyoming and eastern Montana renders it impossible to determine the area of contact between *auduboni* and *canadensis*.

The original range of this race in North Dakota included much of the badland country along and to the west of the Missouri River. Apparently the last individual, an old ram, was killed in the rough hills bordering Magpie Creek in about 1905. (Bailey, 1926:27).

In this connection however it is interesting to note that Maximilian (Thwaites XXIII:246) writing of the country adjacent to Fort Clarke, which was on the Missouri River between the Heart and Knife rivers says "The bighorn *(Ovis montana)* . . . is not found nearer than fifty miles from this part of the country. The Manitories, who go to the Black Hills and other mountainous tracts to hunt, kill a hundred or more of these animals in season." In his trip up the Missouri River he records sighting his first bighorn not many miles below Fort Union, at the junction of the Yellowstone and Missouri rivers (Thwaites XXII:372).

Baird (1857:678) states that "They [bighorn] are not found at any considerable distance east of the Black Hills [South Dakota] however, although said to be abundant in the Mauvaises Terres."

Grinnell (1894) mentions the presence in 1877 of sheep as far east as Birdwood Creek, Nebraska, not far northwest of North Platte City.

How far west the sheep displaying the characters of this race ranged is not known, it seems probable that those inhabiting the Black Hills of northeastern Wyoming were *auduboni*.

*Specimens examined.*—Total number 7.*

NORTH DAKOTA: Medora 31; Mandan 22. SOUTH DAKOTA: Imlay 21.

* For a key to institutions referred to by index figures see p. 541.

TABLE 10.—Cranial measurements of *O. c. auduboni* from North Dakota.

| Museum Number | Approximate age | Basilar length | Nasal length | Nasal width | Orbital width | Zygomatic width | Maxillary width | Mastoid width | Palatal breadth at $M^3$ | Palatal breadth at $Pm^2$ | Upper molar series | Prealveolar length | Post dental length | Width of basioccipital |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Males | | | | | | | | | |
| U.S.N.M. 22610 | (Type) 5 | 285 | 109 | 49 | 116 | 129 | 92 | 92 | 59 | 34 | 94 | 88 | 95 | 28 |
| U.S.N.M. 210285 | Old | | | | 120 | 134 | 98 | 89 | 58 | 32 | 92 | | 95 | 28 |
| | | | | | Females | | | | | | | | | |
| U.S.N.M. 202535 | Old | 261 | 101 | 44 | 115 | 121 | 94 | 87 | 56 | 35 | 90 | 93 | 83 | 26 |
| U.S.N.M 202536 | Young adult | 234 | | 48 | 106 | 120 | 91 | 80 | 52 | 32 | 77 | 74 | 79 | 25 |

TABLE 11.—Comparison of cranial features of *auduboni* and *canadensis*. The first series of data under each measured feature is that of *canadensis*.

| | | N | *Ed² | M | R | O | O′ | V | P |
|---|---|---|---|---|---|---|---|---|---|
| Nasal width | ♀'s | 9 | 47 | 38± .82 | 35–42 | 2.285± .54 | 2.412 | 6.00±1.42 | |
| | | 2 | 8 | 46±2.00 | 44–48 | 2.00 ±1.00 | 2.84 | 4.35±2.17 | Less than .01 |
| Maxillary width | ♀'s | 9 | 74 | 83±1.01 | 79–88 | 2.867± .678 | 3.041 | 3.45± .815 | |
| | | 2 | 5 | 93±1.58 | 91–94 | 1.58 ± .792 | 2.24 | 1.70± .85 | Less than .01 |
| Mastoid width | ♀'s | 9 | 36 | 79± .707 | 76–83 | 2.00 ± .474 | 2.12 | 2.55± .599 | |
| | | 2 | 25 | 84± .353 | 80–87 | 3.53 ±1.77 | 5.0 | 4.22±2.11 | .04 |
| Upper tooth row | ♀'s | 9 | 137 | 85±1.38 | 78–87 | 3.902± .92 | 4.137 | 4.58±1.08 | |
| | | 2 | 85 | 84±6.51 | 77–90 | 6.51 ±3.26 | 9.24 | 7.76±3.88 | Greater than .1 |
| Width of Basioccipital | ♀'s | 9 | 15 | 26± .455 | 24–28 | 1.292± .305 | 1.37 | 4.96±1.17 | |
| | | 2 | 1 | 26± .707 | 25–26 | .707± .354 | 1.00 | 2.72±1.36 | Greater than .1 |
| Upper tooth row | ♂'s | 12 | 200 | 86±1.18 | 78–91 | 4.07 ± .835 | | 4.75± .973 | |
| | | 2 | 2 | 93±1.42 | 92–94 | 1.00 ± .50 | | 1.07± .50 | .04 |
| Width of Basioccipital | ♂'s | 12 | 36 | 32± .5 | 29–35 | 1.73 ± .354 | | 5.42±1.11 | Less than .01 |
| | | 2 | | 28± | 28 | | | | |

*Ed²—sum of the deviations from the mean squared.
P—probability that the two samples could have been drawn at random from the same variable population.

*Ovis canadensis mexicana* Lydekker—MEXICAN BIGHORN

*Ovis mexicanus* Merriam, Proc. Biol. Soc. Wash. *XIV*, 1901: 30; Hornaday, 5th Rep. N. York Zool. Soc. 1900: 120; Stone and Cram, Amer. Mamm. 1903: 64. Bailey, N. Amer. Fauna No. 25, 1905: 70, Lyon & Osgood, U. S. Nat. Mus. Bull. 62, 1909: 11.

*Ovis canadensis mexicana* Lydekker, The Sheep and Its Cousins, 1912: 289; Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 116; Seton, Lives of Game Animals **3**, 1927: 522; Bailey, N. Amer. Fauna No. 53, 1931: 20.

*Ovis canadensis mexicanus*, Lydekker, Great and Small Game of Europe, etc. 1901: 11, Mearns, Mamm. U.S. and Mex Bound. Surv. **1**, 1907: 232.

*Ovis cervina mexicanus*, Elliot, Zool. Publ. Field Mus. **5** 1904: 86; Zool. Publ. Field Mus. **6**, 1905: 54.

*Ovis cervina mexicana*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 26.

*Ovis canadensis gaillardi* Mearns, Mamm. U.S. and Mexican Boundary Survey **1**, 1907; 240: (Between Tinajas Altas and Mexican Boundary, Yuma County, Arizona); Hornaday, Campfires on Desert and Lava 1908; Lyon & Osgood, U.S. Nat Mus. Bull. 62, 1909; 10; Lydekker, The Sheep and Its Cousins 1912: 291; Cat Ung. Mamm. Brit. Mus. **1**, 1913: 116; Miller, Bull. U.S. Nat. Mus. No. 128, 1923: 496; Seton, Lives, **3**, 1927: 522; Anthony, Field Book of Mammals, 1928: 544; Dice and Blossom, Carnegie Inst. Wash. Publ. 485, 1937: 44; Burt, Misc. Publ. No. 39, Mus. Zool. Univ. Mich. 1938: 73.

*Ovis cervina gaillardi*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912:27.

*Ovis mexicana*, Miller, Bull. U.S. Nat. Mus. No. 128, 1923: 497.

*Ovis canadensis texianus* Bailey, Proc. Biol. Soc. Wash. **25**: 109, 1912. (Guadalupe Mts., El Paso Co., Texas)

*Ovis canadensis texiana*, Bailey, 1931, Mammals of New Mexico. N.A.F. No. 53, p. 18-20. Anthony, Field Book of Mamm. 1928: 544. Miller, Bull. U.S. Nat. Mus. No. 128: 496, 1923. Seton, Lives of Game Animals, **3**, 523, 1927.

*Ovis sheldoni* Merriam, Proc. Biol. Soc. Wash. **29**, 1916: 130 (El Rosario, Sonora, Mexico); Seton, Lives **3**, 1927: 523; Dice and Blossom, Carnegie Inst. Wash. Publ. 485, 1937: 44. Burt, Misc. Publ. No. 39, Mus. Zool. Univ. Mich. 1938: 75.

*Type.*—In United States National Museum, Biological Survey Collection, Number 99342, adult male, taken near Lake Santa Maria, Chihuahua, Mexico, Sept. 16, 1899, by E. W. Nelson and E. A. Goldman. Original number 13974.

*Range.*—The mountain ranges of Mexico, extreme southwestern Texas, southern New Mexico and Arizona; south in Sonora to Seriland, opposite Tiburon Island; in western and northwestern Arizona along the valley of the Colorado River intergrading with *cremnobates*, *nelsoni* and *canadensis*.

*Diagnosis.*—A pale, desert race of bighorn with long ears, a short broad skull and relatively short moderately spreading horns.

*Measurements.*—Adult male from type locality: Total length 60 inches (1530 mm.), tail 8 inches (130 mm.), hind foot 17 inches (425 mm.), height at shoulders 35 inches (900 mm.). Adult male from Quadalupe Mountains, Texas, measured when dry, 1490, 70, 370, (in inches 58, 2¾, 14½) ear from notch 95 mm. Young adult male from Pinacate: Total length 1060, height at shoulder 925 mm.; adult male (type of *sheldoni*) total length

Basioccipital | 2 | 28±

*Ed²—sum of the deviations from the mean squared.
P—probability that the two samples could have been drawn at random from the same variable population.

"under" 52 inches (1326 mm.); tail 3⅞ inches (94 mm.); hind foot 14 inches (357 mm.); height at shoulder "under" 30 inches (765 mm.).

Females measured as follows: Adult from type locality 1480, 130, 405, 880; adult from Quadalupe mountains, measured dry, total length 1530, hind foot 370, ear from notch 90; three or four year old female (type of *gaillardi*) 1200, 120, 315, 770, ear from crown 120.

Height of ear from notch in four adult males from type locality (measured dry) 106 (95-120).

*Color.*—The color of seven September topotypes varies little. They are paler than any of the other races examined in comparable pelage with the possible exception of *cremnobates*. Dorsal color between pale Vinaceous Fawn and Vinaceous Buff, tail Wood Brown; lower legs between Avelaneous and Wood Brown; much white on abdomen and extending forward narrowly onto chest. Narrow white line down fore and hind legs. Face and ears brownish white.

Dorsal coloration of a September specimen from the Quadalupe Mountains, Texas, Vinaceous Buff with a suggestion or drab gray; somewhat darker along mid-dorsal line, neck and on lower legs approaching Verona Brown on the latter; abdomen, axillae and inguinal region white; hind legs white on inner surface between hock and dew claws, fore legs white medially to dew claws; nose whitish, tail stripe not complete across white rump patch.

The body color of a December specimen from the Gila Mountains, Arizona, is best described as Verona Brown, that of a February specimen from the same locality is considerably paler, nearest Wood Brown. In both the face is paler, the nose and lower lip whitish, the belly, inguinal region, inside of legs white. The rump patch is white, sometimes divided by tail stripe, but generally not so. Vertebral stripe generally obsolete. Ears brown outside, whitish inside.

*Horns.*—Similar in color to other desert races, tapering more rapidly than those of *nelsoni* and not so divergent. The two adult males from the Quadalupe Mountains, Texas, agree in having the orbital corner of the horns produced onto the face in round lobe.

*Cranial Comparisons.*—An extended discussion of the differences between skulls male and female of *mexicana* and those of *canadensis*, is given in the treatment of the latter race. It is needless to repeat such here. Suffice it to say that female *mexicana* have the skulls much the same general size as in *canadensis*, but have the nasals broader, zygomatic width less, maxillary width less, post palatal width less and tooth rows longer and heavier than in the northern race.

Male *mexicana* on the other hand have the skull significantly shorter, mastoid width, prealveolar length, postdental length and post-palatal width less and the upper tooth row relatively longer, averaging 34 per cent of the basilar length as against 30 per cent in *canadensis*.

*Remarks.*—In the original description of *gaillardi* (Mearns 1907:240) this

supposed race was stated to differ from *mexicana* in having the molars smaller and the horns strongly incurved and with a wide space between their bases. The former has been shown not to be the case, the two latter peculiarities occur as variants in almost all the races studied. The characteristics ascribed to *gaillardi* then are further testimony to the inadvisability of describing races of large mammals on one or two specimens.

The differentiation of sheep from southern Arizona and Sonora *"gaillardi"* and those from Texas and Chihuahua *(mexicana)* is most unsatisfactory. The measured series of *mexicana* ewes averages larger than *"gaillardi"* in all features save zygomatic width, post-palatal breadth and lengths of post-dental area and prealveolar length, however, in no instance is the observed difference significant. The length of the upper tooth row (P=.1) comes nearest to being so.

Similarly in the males there is no feature of significant difference in the

TABLE 12.—Cranial measurements of *mexicana* males from type locality.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 3 | 261±2.36 | 257–265 | 3.32±1.35 | 4.06 | 1.27± .52 |
| Nasal length | 2 | 115 | 115 | | | |
| Nasal width | 3 | 56±3.36 | 49–59 | 4.75±1.94 | 5.80 | 8.45±3.45 |
| Orbital width | 9 | 120± .91 | 117–121 | 1.29± .526 | 2.24 | 1.07± .44 |
| Zygomatic width | 3 | 125±4.72 | 117–132 | 6.68±2.73 | 8.20 | 5.35±2.18 |
| Maxillary width | 3 | 90±2.36 | 86–94 | 3.32±1.35 | 4.06 | 3.68±1.36 |
| Mastoid width | 3 | 87±1.47 | 84–89 | 2.08± .849 | 2.54 | 2.39± .845 |
| Palatal breadth at $M^3$ | 3 | 56±1.47 | 54–59 | 2.08± .849 | 2.54 | 3.57±1.53 |
| Palatal br. at $Pm^2$ | 3 | 35± .707 | 34–36 | 1.00± .408 | 1.25 | 2.85±1.17 |
| Molar series | 3 | 87±1.87 | 83–89 | 2.64±1.08 | 3.23 | 3.04±1.24 |
| Prealveolar length | 3 | 81±2.66 | 78–86 | 3.78±1.54 | 4.62 | 4.63±1.89 |
| Post dental length | 3 | 88±3.76 | 81–94 | 5.3 ±2.17 | 6.52 | 6.04±2.46 |

* For explanation of symbols see page 516.

TABLE 13.—Cranial measurements of *O. c. mexicana* female topotypes.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 3 | 249±1.99 | 247–253 | 2.83±1.15 | 3.46 | 1.13± .461 |
| Nasal length | 3 | 102±2.62 | 97–106 | 3.70±1.51 | 4.52 | 3.62±1.48 |
| Nasal width | 3 | 45±1.78 | 42–48 | 2.52±1.05 | 3.08 | 5.6 ±2.28 |
| Orbital width | 3 | 108±2.64 | 104–113 | 3.75±1.55 | 4.57 | 3.45±1.52 |
| Zygomatic width | 3 | 115± .50 | 114–115 | .577±.228 | .707 | .61± .25 |
| Maxillary width | 3 | 92±1.35 | 82–93 | 1.91± .78 | 2.34 | 2.08± .85 |
| Mastoid width | 3 | 77± .75 | 76–78 | 1.00± .407 | 1.22 | 1.30± .916 |
| Palatal breadth at $M^3$ | 3 | 55 | 55 | | | |
| Palatal br. at $Pm^2$ | 3 | 32 | 32 | | | |
| Upper molar series | 3 | 91±2.04 | 88–95 | 2.88±1.18 | 3.54 | 3.18±1.29 |
| Prealveolar length | 3 | 78± .50 | 77–78 | .577±.288 | .707 | .74± .302 |
| Post dental length | 3 | 80±1.99 | 76–82 | 2.83±1.15 | 3.46 | 3.51±1.44 |

TABLE 14.—Cranial measurements of *O. c. mexicana* males from southwestern Arizona and northern Sonora.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 5 | 261±1.33 | 256–265 | 3.06± .97 | 3.42 | 1.18± .59 |
| Nasal length | 7 | 112±2.3 | 100–119 | 5.64±1.50 | 6.07 | 5.03±1.35 |
| Nasal width | 7 | 51± .99 | 48–54 | 2.33±6.24 | 2.52 | 4.57±1.22 |
| Orbital width | 7 | 119± .986 | 114–122 | 2.42± .645 | 2.61 | 2.03± .545 |
| Zygomatic width | 7 | 130±1.44 | 124–134 | 3.27± .94 | 3.53 | 2.70± .722 |
| Maxillary width | 7 | 95±1.3 | 91–100 | 3.02± .807 | 3.27 | 3.18± .855 |
| Mastoid width | 6 | 90±1.45 | 85–94 | 3.24± .935 | 3.54 | 3.60±1.04 |
| Palatal breadth at M3 | 6 | 58± .366 | 57–59 | .82± .236 | .89 | 1.43± .41 |
| Palatal br. at $Pm^2$ | 6 | 35± .710 | 33–37 | 1.58± .434 | 1.73 | 4.50±1.34 |
| Upper molar series | 7 | 89± .972 | 84–91 | 2.39± .637 | 2.58 | 2.68± .715 |
| Prealveolar length | 6 | 81±1.11 | 78–84 | 2.27± .716 | 2.49 | 3.06± .885 |
| Post dental length | 6 | 88±1.51 | 83–91 | 3.08± .977 | 3.38 | 3.85±1.11 |

* For explanation of symbols see page 516.

TABLE 15.—Cranial measurements of *O. c. mexicana* females from southwestern Arizona and northern Sonora.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 4 | 243±4.70 | 230–250 | 8.17±2.88 | 9.40 | 3.35±1.18 |
| Nasal length | 6 | 99±1.60 | 94–103 | 3.22±1.03 | 3.54 | 3.62±1.04 |
| Nasal width | 6 | 39±1.17 | 35–41 | 2.62± .750 | 2.86 | 6.65±1.93 |
| Orbital width | 6 | 103±2.74 | 95–112 | 6.12±1.77 | 6.70 | 5.95±1.72 |
| Zygomatic width | 6 | 116±2.28 | 107–123 | 5.10±1.47 | 5.60 | 4.40±1.27 |
| Maxillary width | 6 | 86±1.63 | 83–91 | 3.65±1.05 | 4.0 | 4.24±1.22 |
| Mastoid width | 5 | 73± .895 | 72–76 | 1.79± .566 | 2.0 | 2.45± .775 |
| Palatal breadth at M3 | 5 | 53±1.66 | 52–55 | 1.27± .40 | 1.41 | 2.38± .755 |
| Palatal br. at $Pm^2$ | 5 | 31±1.05 | 30–35 | 2.1 ± .665 | 2.34 | 6.75±2.14 |
| Upper molar series | 6 | 86±1.50 | 81–90 | 3.36± .970 | 3.68 | 3.90±1.13 |
| Prealveolar length | 6 | 78±1.33 | 74–80 | 2.97± .856 | 3.25 | 3.80±1.10 |
| Post dental length | 5 | 79±2.22 | 71–84 | 4.45±1.41 | 4.96 | 5.62±1.78 |

two small series available for comparison. Males of *mexicana* tend to have the anterior portion of the rostrum narrower, thus the prealveolar length which has essentially the same mean length in both populations is 89 per cent of the maxillary breadth in *mexicana*, 85 per cent in "*gaillardi*." Here again the range of variation and small number of specimens renders the results unreliable. The values of P for the comparison of maxillary breadths and the mastoid is in each case about .05 and that for the zygomatic widths less than .1 and do not justify recognition of a separate race in southwestern Arizona.

Furthermore the presence of one abnormally small individual, which is at the same time the youngest individual, in the series of *mexicana* complicates the comparisons of these two populations.

If this specimen is withdrawn from the series the means in almost every case are close enough to be considered identical. Only width of combined

nasals and maxillary width have means differing by as much as 5 mm. (P between .1 and .05).

It should be noted also that the only locality within the supposed range of *"gaillardi"* from which a series of specimens is available lies adjacent to territory occupied by sheep populations displaying to a normally uniform degree the characteristics we consider as typifying *cremnobates*. The ratio of maxillary breadth to diastema in that race is 85 per cent precisely that displayed by the population of southeastern Arizona. At the same time the supposed race *"gaillardi"* occupies a geographic position between *nelsoni, mexicana, cremnobates* and *canadensis* and the characteristics displayed in the different parts of its range appear to be somewhat of a compromise.

The slightly darker color of specimens from western Arizona when compared with seasonally equivalent specimens from Chihuahua if it is constant enough to be valid, may indicate a tendency of the Arizona specimens to approach *nelsoni*.

Many of the adult males from this same area have the horns larger than do any of the few specimens from Chihuahua examined. So also do *cremnobates, nelsoni* and *canadensis* and is as much as the specimens of *"gaillardi"* in question come from areas adjacent to these latter races I interpret the observed horn characters as the result of intergradation between one or more of these races and *mexicana*.

I may err in placing the bulk of the specimens hitherto referred to *"gaillardi"* into the race *mexicana*. Those from southwestern Arizona as has already been pointed out differ very little from *nelsoni*, even less from *mexicana*. It may be that the fortuitous combination of characteristics resulting from the blending of *nelsoni* and *cremnobates* have by chance produced a population resembling *mexicana* in the only area from which I have a series available. However the sum of the characters displayed by *"gaillardi"* seems to indicate its treatment as *mexicana*, as the only logical course to follow. It is possible that the acquisition of further specimens, particularly from south central Arizona, may necessitate a revision of this conception, but in light of present material there are neither external nor cranial characters to support the recognition of more than one race of sheep in the area here ascribed to *mexicana*.

The museum collections I have examined contained but two adult males and one young adult female representing the population of bighorns of Texas. Of these the two males have the mean nasal length and combined widths of nasals shorter than that of the *mexicana* males but both components well within the range of variability of the latter. In both these measurements the value of P is much in excess of .1 and consequently the observed difference cannot be regarded as even probably significant. In his description of *"texiana"* Bailey states that the new race differs "from all other species of the United States and Mexico in the relatively narrow muzzle, nasals and palate in both sexes." As has already been stated the nasals of the two males are actually shorter and narrower but not significantly so. Similarly the nasals of the Texas specimens are relatively narrower, ratio, width to length 44 per cent as against

TABLE 16.—Cranial measurements of male and female *O. c. mexicana* from the Guadalupe Mountains, Texas.

| Museum number | Approximate age | Basilar length | Nasal length | Nasal width | Orbital width | Zygomatic width |
|---|---|---|---|---|---|---|
| | | | | | | Males |
| U. S. N. M. 110047 | 6 | 268 | 107 | 47 | 114 | 118 |
| U. S. N. M. 110388 | 6 | | 103 | 45 | 113 | 123 |
| | | | | | | Females |
| U. S. N. M. 118255 | 4 | 246 | 110 | 36 | 100 | 113 |

| Museum number | Maxillary width | Mastoid width | Palatal breadth at $M^3$ | Palatal breadth at $Pm^2$ | Upper molar series | Prealveolar length | Post dental length |
|---|---|---|---|---|---|---|---|
| U. S. N. M. 110047 | 86 | 85 | 53 | 35 | 87 | 85 | 87 |
| U. S. N. M. 110388 | 92 | 85 | 55 | 37 | 84 | 85 | 88 |
| U. S. N. M. 118255 | 86 | 74 | 51 | 30 | 92 | 79 | 78 |

48 per cent in *mexicana*, but here again the difference is not significant. As for the width of the rostrum and palate my measurements fail to substantiate Bailey's statement. Means of Texas and Chihuahua specimens as regards maxillary width differ by 1 mm. palatal breadth at $M^3$ by 2 mm. and palatal breadth at $Pm^2$ by 2 mm. In the latter the Texas specimens exceed those from Chihuahua.

The upper molar rows of the males from Texas are more nearly parallel than is the case in the series of *mexicana* from Chihuahua the ratio palatal breadth at $Pm^2$ to palatal breadth at $M^3$ 66 per cent in the Texas specimens, 60 per cent in *mexicana* topotypes. This difference comes nearer to significance than any other I have been able to discover, as $P = .04$.

The single female from Texas differs from the series of *mexicana* in longer, narrower nasals and narrower maxillary region and palate. In order to be significant the value of any measurement for the single specimen must vary from the mean of the sample of *mexicana* by an amount equal to at least four times the standard deviation of the mean of the sample. This is not the case in any one of the above features.

I have been unable to detect any valid differences in skull form not reflected in the twenty-two cranial measurements taken for analysis, nor in

any external features of form or color to justify the recognition of a separate race inhabiting the mountains of Texas.

It will be understood however that the above analysis does not prove that the sheep of Texas and Chihuahua belong to the same variable population. It shows only that on the basis of specimens now in hand it is not possible to prove that they do not belong to the same race. As I see it, the evidence is that when more specimens are available it may become possible to demonstrate the existence of two different populations there. However, if taxonomy is to occupy a place of any utility in the field of vertebrate zoology species and subspecies must not be described on speculation.

In the interest of shedding more light on the actual relationship between the sheep of Texas and Chihuahua it is urged that all game wardens, hunters and others finding skulls of sheep in the mountains of Texas take pains to see that they are deposited in a museum, where they will be cared for and may contribute to our knowledge of the sheep of that part of North America.

The small ram from El Rosario, Sonora, which, with a ewe from the same place formed the basis for *Ovis sheldoni* Merriam provides an interesting situation capable of two or more interpretations.

Merriam, observing the markedly distinct characteristics possessed by the ram, and believing he saw corroborative evidence in the partial skull of the female specimen, assumed the observed differences were of genetic origin and of geographic association (vide his description of the new species).

The ram, in comparison with skulls from adjacent ranges in Arizona and Sonora has the skull smaller than average in all features, but most pronouncedly so in orbital breadth, maxillary breadth, palatal breadth at $M^3$ and at $Pm^2$. In these features the measurements of the El Rosario ram are removed more than four standard deviations from the corresponding means of the series of seven comparable males and are therefore significantly different. In this ram also the facial part of the skull is foreshortened in relation to the cranial portion.

The skull of the ewe, on the other hand while it is below the mean of the series of comparable ewes from adjacent ranges, it is within the observed range of variation in all features except mastoid breadth, width of palate at $Pm^2$ and diastema. In the first two it is removed from the mean of the sample by less than two but more than one standard deviation, in the latter by just two standard deviations. Consequently it is well within the bounds of probability that the El Rosario ewe could have been part of the same variable population as those of the adjoining ranges.

In deer of the genus *Odocoileus* I have found that poor food conditions during the growth period and particularly isolation of a population on a small island, causes the deer to degenerate in size. This degeneration is accompanied by a foreshortening of the rostral portion of the skull and a general slenderness of this area, all of which are signs of ontogenetic immaturity and indicate arrested development. Consequently if it were not for certain other sheep specimens examined I would favor an analogous explanation of the conditions

displayed by the El Rosario ram, and in any case this may be the correct one.

However I have encountered six dwarfed specimens of sheep in the museums of North America. All are males. Two are complete skulls from one hundred and twenty-five miles southeast of Yuma, Arizona; one is a fragmentary skull from "California," one a complete skull from near Lillooet, B. C., and another is represented by a single horn from Nevada. I suspect that the type of *O. c. similkameenensis* is another such. In each case, except from El Rosario, skulls or partial skulls of normal rams are available from the same localities.

The type of *Ovis storki* from Kamchatka bears suspicious similarity to dwarfed individuals of the American races.

Thus it would seem that dwarfism, arising either from glandular disfunction, mutation, or some other cause is relatively abundant in the sheep population. Such individuals obviously cannot be considered as part of the "normal" population for the purpose of studies such as this.

It is apparent of course that the statistical treatment of numerical data, of the type employed in this study can reveal "significant differences" but cannot indicate to what factors these differences are attributable. Before these differences can be treated as probably of a genetic nature associated with geographic distribution all other reasonable explanations must be exhausted. There seems to be at least as great if not a greater probability that the characteristics exhibited by the type of *O. sheldoni* have no geographic correlation, as that they do have such. It follows that it has yet to be shown that a recognizably different population of sheep exists on Sierra El Rosario.

*Status.*—The range of the bighorn in Texas as it existed in 1905 is described by Bailey (1905:70) as including the Upper Sonoran and Transition zones of the desert ranges of extreme western Texas. They were still found in the Guadalupe Mountains in the Eagle, Chisos, and Corozones mountains and individuals had been taken in the Diabolo Mountains, twenty-five miles north of Van Horn. They worked up the Grand Canyon of the Rio Grande from the Mexican side. Bailey( idem) writes further that 'they easily wander from range to range over a wide expanse of country in western Texas, and might be considered to have an almost or quite continuous distribution between Guadalupe Mountains and the desert ranges of Chihuahua."

The same author (1931:18) expresses himself as doubtful of the existence of any mountain sheep of this race in New Mexico except for a few in the Guadalupe and San Andres Mountains.

Davis and Taylor (1939:440) gives an excellent summary of the status of bighorn in Texas. They report them as still present casually or permanently in the Guadalupe Mountains, Delaware Mountains, Sierra Diablo, Baylor Mountains, Apache Mountains, Beach Mountains, Carrizo Mountains, Eagle Mountains, and Cienega Mountains to the possible total number of three hundred head.

Sonora, Mexico.—Recorded from Sierra Cabota, Sierra Nariz, Sonoyta and

Seriland in the province of Sonora, Mexico, by Mearns (1907:244) and from Sierra Pinacate by Hornaday (1908). I have been unable to obtain any precise information regarding the present status of this race in the Mexican part of its range.

Arizona.—Mearns (1907:239) reported bighorn in the Santa Rita and Santa Catalina mountains. Dice and Blossom (1937:44) cite D. I. MacDougal as authority for the statement that as recently as 1930 a few individuals still occurred on the lower slopes of the Santa Catalina Mountains near the mouth of Pima Canyon and elsewhere.

Blossom (Dice and Blossom ibid.) saw signs of the presence of this sheep in the Tinajas Altos and at Tule Tank in 1932 and 1933 and at Papago Tanks in 1933.

Mr. A. A. Nichol of Tucson, Arizona, has been conducting an extensive reconnaissance of the sheep situation in that state. He reports approximately seventeen sheep seen in the Ajo Mountains, five in the Puerto Blanco Mountains, three in the Bighorn Mountains, twelve in the northeastern half of the Eagle Tail Mountains, twenty-four in the Rawhide Mountains, sixteen on the Black Mesa of the Alamo, nine in the Chemchuevi Mountains, eight to twelve on Aquarius Cliffs, eleven in the Lower Santa Maria drainage, ten in the Aqua Dulce Mountains, ten in the Sierra Pinto Mountains, four-teen in the south half of the Mohawk Mountains, fifteen in Castle Dome Mountains, and from fifty to seventy-eight in the Arizona strip from Toroweap Valley west and north to St. George Utah.

The same authority gives an approximate census for 1937 (in lit. May 12, 1939) as follows: Granite Mountains 10, Aquila Mountains 4, Gila Mountains, not including the Tinajas Altos 15, Kofas 25, Trigos 10-15, Chocolate Mountains 6-7, Buckskin Mountains 10-12, west end of Harcuvar Mountains 7-8, Black Mountains (main range exclusive of Oatman district) 60-75, Superstition Mountains 47. In addition Mr. Charles T. Vories adds that there were known to be at least six in the Tucson Mountains and about seventy-one in the Santa Catalina Mountains in the autumn of 1937.

Chihuahua.—I have been unable to obtain any authentic information on the present status of bighorn in this in this part of Mexico.

New Mexico.—Fragmentary specimens obtained in the Dog Mountains, Grant County, southern New Mexico by Mearns and Holzner (Mearns, 1907:235) though displaying no differential characters are referred to this race by Mearns (idem) and Bailey (1931:20). This seems to be the logical assignment for purely geographic reasons. The former distribution of this sheep in New Mexico is discussed at length by Bailey (idem). He found reliable evidence of their presence at an earlier period in the Cloverdale Range, in the Burrow and Carlisle Mountains as well as in the Mogollon Mountains and in the little ranges from the Magdalenas to the Zuni Mountains.

*Specimens examined.*—Total number 81.*

* For a key to institutions referred to by index figures see p. 541.

CHIHUAHUA, MEXICO: Lake Santa Maria 101; Cerro Chino 62; Chihuahua 12; St. Chihuahua 18; Ahumada 18; Forty Miles east of Gallego 19.

SONORA, MEXICO: Tule Mountains, 10 miles south of Boundary Monument 186, 69'1; Eastern Peak of Pinacate 15; Crater Elegante 15; Aqua Dulce 12, south of Tucson 32; Tinajo d. Cuervo, Pinacate 42, Mountains of El Viajo 18; Pinacate Mountains 116'1; Sierra Seri 41; Gila Mountains 11; Costa Rica Ranch 21, Hombre Viejo Mountains 11.

TEXAS: Quadalupe Mountains 41; Van Horn 11.

ARIZONA :Sierra del Ajo, south of Gilabend 18; Gila Mountains 41; Copper Mountains 21; Tule Tank 11; Cabeza Prieta Mountain 11; Tule Mountains 11; Vicksburgh 11; Tinajas Altas 51, 16 miles north of Boundary Monument 179, Yuma County 91.

### *Ovis canadensis californiana* Douglas—CALIFORNIA BIGHORN

*Ovis californianus* Douglas, Zool. Journ. **4**, 1829: 332.

*Ovis californiana*, Biddulph, Proc. Zool. Soc. 1885: 683; Hollister, Proc. Biol. Soc. Wash. **25**, 1912: 187.

*Ovis californica*, Richardson, Fauna Bor.-Amer. **1**, 1829: 272; Bailey, Nat. Hist. **18**, No. 5, 1931: 279.

*Ovis canadensis californiana*, Lydekker, The Sheep and Its Cousins, 1912: 288, Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 113; Miller, Bull. U.S. Nat. Mus. No. 128, 1923: 495; Seton, Lives **3**, 1927: 522; Anthony, Field Book of Mammals, 1928; 544; Taylor and Shaw, Occ. Papers Chas. R. Connor Mus. No. 2, 1929: 31; Grinnell, Univ. Calif. Publ. Zool. **40**, No. 2, 1933: 210; Anderson, Trans. 3rd N. Amer. Wildlife Conf. 1938: 402.

*Ovis canadensis*, Anderson, B. C. Prov. Mus. Rept. (1913), 1914: G18. Brooks. Canad. Field Nat. **37**, 1923: 23 (part); Moran, Canad. Field Nat. **42**, 1928: 12 (part).

*Ovis canadensis samilkameenensis* Millais, The Gun at Home and Abroad **4**, 1915: 324 (Similkameen Mts., B. C.) [Seton, 1927 and Anthony 1928 erroneously listed this as a race and a synonym respectively of *O. d. stonei*.]

*Ovis canadensis sierrae*, Lydekker, The Sheep and Its Cousins, 1912: 290; Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 115; Seton, Lives **3**, 1927: 522; Miller, Bull. U.S. Nat. Mus. No. 128, 1927: 496; Grinnell, Univ. Calif. Publ. Zool **40**, No. 2, 1933: 210.

*Ovis cervina californiana*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 25; Grinnell Univ. Calif. Publ. Zool. **10**, 1912: 150; Hollister, Proc. Biol. Soc. Wash. 25, 1912: 187.

*Ovis cervina cervina*, Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 25 (part).

*Ovis cervina sierrae* Grinnell, Univ. Calif. Publ. Zool. **10**, 1912: 144. (east slope of Mt. Baxter, Sierra Nevada, Inyo Co., Calif.)

*Ovis dalli ellioti* Kowarzig, Zool. Anz. **41**, 1913: 444 (Fraser Valley, B. C.) nomen nudum.

*Type.*—In British Museum: No. 52.9.18.5; skull and horns of adult male taken August 27, 1826, near Mt. Adams, Yakima County, Washington, by David Douglas.

*Range.*—Formerly from the Chilcotin River. British Columbia south through the Cascades of Washington and Oregon and the Sierra Nevada of California to the vicinity of Mount Whitney.

*Diagnosis.*—Smaller than *canadensis* and with more slender, divergent and narrow pointed horns; color indistinguishable from that race.

*Measurements.*—The measurements of the type specimen are given (Douglas 1828:332) as, Total length 5′10″, height at the shoulder 2′ 8″, length of tail 1′6″, ears 1½″ long. This tail measurement is evidently erroneous. Three males from Owens Valley (the type of *sierrae* and two topotypes) measure as follows: 3 year old, 1445 mm., 70, 400; 5 year old, 1582, 110, 420; 4 year old, 1570, 100, 420; a 4 year old female from the same locality measures 1385, 70, 395.

*Horns.*—Light brown, somewhat slender, not closely curled as in *canadensis*, tips usually entire.

*Color.*—Not differing appreciably from *canadensis*. An adult male from the Chilcotin district of British Columbia, shot in early September had upper parts of body between Benzo brown and Drab; legs darker, Mummy brown outside, whitish inside; neck same as back, somewhat darker on crown, face grayer back of ears grayish, front white; abdomen and brisket white, rump patch white divided dorsally by dark tail stripe; tail Bister. A somewhat faded winter specimen from the North Fork of the Methow River, Washington, is identical with comparable specimens of *canadensis*. Dorsal surface and sides about Wood Brown; legs darker Verona Brown to Snuff Brown. The amount of white on the underparts is variable and may be entirely absent as in Amer. Mus. No. 14478 from the Cascade Mountains of British Columbia.

*Comparisons.*—Slightly smaller than *canadensis* and with the brown of the dorsal areas exhibiting a grayish rather than a reddish cast in comparison with that race. The range of individual variation however is great and many individuals of the two races are not distinguishable from one another externally.

*Cranial comparisons.*—In the series measured, skulls of female *californiana* average larger than those of *nelsoni* in all dimensions except post-palatal width and the three figures representing horn size and shape. In these the latter race is

TABLE 17.—Cranial measurements of *O. c. californiana* females from southern British Columbia and Washington

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 4 | 243±4.13 | 237–255 | 7.15 ±2.52 | 8.27 | 2.94±1.04 |
| Nasal length | 5 | 101±3.23 | 92–110 | 6.47 ±2.04 | 7.42 | 6.40±2.02 |
| Nasal width | 5 | 39±1.64 | 35–44 | 3.28 ±1.04 | 3.68 | 8.43±2.67 |
| Orbital width | 5 | 105±1.46 | 103–110 | 2.93 ± .925 | 3.26 | 2.79± .882 |
| Zygomatic width | 5 | 119±1.46 | 116–123 | 2.93 ± .925 | 3.26 | 2.46± .779 |
| Maxillary width | 5 | 86±1.52 | 82–91 | 3.03 ± .960 | 3.40 | 3.52±1.12 |
| Mastoid width | 4 | 79±1.12 | 77–82 | 1.93 ± .682 | 2.24 | 2.45± .865 |
| Palatal breadth at $M^3$ | 5 | 53±1.43 | 48–55 | 2.86 ± .905 | 3.20 | 5.39±1.71 |
| Palatal br. at $Pm^2$ | 5 | 29±1.38 | 26–34 | 2.75 ± .871 | 3.08 | 9.50± .30 |
| Upper molar series | 5 | 86±2.63 | 82–96 | 5.25 ±1.67 | 5.86 | 6.10±1.93 |
| Prealveolar length | 5 | 79±1.65 | 75–84 | 3.31 ±1.05 | 3.70 | 4.20±1.33 |
| Post dental length | 4 | 77± .388 | 76–78 | .775± .245 | .865 | 1.00±3.18 |

* For explanation of symbols see page 516.

slightly but not significantly larger. *Californiana* females have the basilar length, orbital width, zygomatic width, mastoid width, least palatal length and prealveolar length significantly greater than *nelsoni* and in addition nasal length (P=less than .02), maxillary width (P between .01 and .02) and nasal width (P=.05) are larger and in the first two instances at least will probably prove to be significantly so.

Comparison of my measured series of *californiana* males (see p. 517) from British Columbia and Washington and of the series of *nelsoni* males from the desert areas of southeastern California and southwestern Nevada reveals an astounding correspondence in the mean values of all measurements. Those of the horns differ more than do any of the others. In these *californiana* is considerably smaller in all three dimensions but in view of the great range of variation the differences are not significant. Except by a general picture of horn form, more readily apparent to the eye than demonstrable by valid figures I have been unable to discover any feature or combination of features by which skulls of male *californiana* and *nelsoni* can be distinguished.

There are however external differences, mentioned above, and the significantly different cranial features exhibited by the females of these two races.

The only other race with range adjoining that of *californiana* is *canadensis*. A detailed discussion of the features serving to distinguish these races from each other has been given in the discussion of *canadensis*.

*Remarks*.—On the basis of specimens from the eastern slope of the Sierra Nevada of California is the latitude of Owens Valley, Grinnell (1912) described a race *sierrae*. At that time no specimens of *californiana* were available for comparison.

Five adult rams from the Sierra Nevada of California have the skulls resembling *nelsoni* as regards basilar length, orbital width, palatal breadth at $M^3$ and $Pm^2$, and post-dental length; resembling *californiana* in length of upper tooth row and form of horns; intermediate between these two as regards mastoid width and prealveolar length. At the same time the Sierra Nevada series have the nasals shorter and narrower, the zygomatic width slightly less and the maxillary width slightly greater than the corresponding measurements in both *nelsoni* and *californiana*. However the differences in mean values of these cranial features is small (see tables 3, 18, 20 and 21) and not significant in any one case. These sheep cannot properly be referred to either naemd race and yet do not differ from them to a degree that would justify the recognition of a separate race "*sierrae*" in that area. It seems to me that the sheep of the Sierra Nevada represent a population of intergrades in which can be seen incipient racial characteristics.

Specimens from the Tin Mountains, Inyo County, apparently represent a population of intergrades between the Cascade and desert sheep.

The specimen from the Similkameen Mountains of southern British Columbia upon which the name *samilkameenensis* is based (Millais) while not examined by me is almost certainly one of the occasional dwarfed individuals. Other skulls from this area do not exhibit the peculiarities assigned to *samilkameenensis* by Millais. Six skulls from the mountains adjacent to the

TABLE 19.—Cranial measurements of *O. c. california* males from the Sierra Nevada, California.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 5 | 260±6.77 | 247–275 | 13.6 ±4.29 | 15.2 | |
| Nasal length | 5 | 109±2.84 | 99–116 | 5.71±1.80 | 6.39 | 5.24±1.66 |
| Nasal width | 5 | 55±2.16 | 49–61 | 4.32±1.37 | 4.83 | 7.82±2.48 |
| Orbital width | 4 | 119±3.23 | 114–128 | 5.43±1.92 | 6.27 | 4.98±1.76 |
| Zygomatic width | 6 | 128±2.36 | 120–134 | 5.27±1.52 | 5.75 | 4.10±1.19 |
| Maxillary width | 6 | 95±2.06 | 86–101 | 4.60±1.33 | 5.05 | 4.85±1.40 |
| Mastoid width | 5 | 91±1.61 | 87–94 | 3.22±1.02 | 3.60 | 3.53±1.12 |
| Palatal breadth at M3 | 6 | 55±1.14 | 53–59 | 2.55± .735 | 2.79 | 4.62±1.33 |
| Palatal br. at Pm2 | 6 | 33±1.36 | 29–38 | 3.05± .880 | 3.34 | 9.24±2.66 |
| Upper molar series | 6 | 88±1.79 | 80–95 | 4.0 ±1.15 | 4.47 | 4.53±1.31 |
| Prealveolar length | 3 | 83±4.78 | 72–86 | 6.77±2.76 | 8.30 | 8.15±3.32 |
| Post dental length | 3 | 90±3.94 | 81–93 | 5.60±2.27 | 6.83 | 6.20±2.53 |

* For explanation of symbols see page 516.

Similkameen Valley display no characteristics warranting the recognition there of a race distinct from *californiana.*

The acquisition of additional material from Washington and British Columbia fails to substantiate Hollister's (1912:184) suggestion that the Cascade Mountain sheep resembles the thin-horned sheep rather than the bighorn.

*Status.*—British Columbia: In this province is found the largest remaining population of California bighorn. Sheep of this race were formerly abundant in the Ashnola and Similkameen mountains adjacent to the remnant herd in the state of Washington. There are still some sheep in the area but the number is small. Small bands are present in the mountains adjacent to Vasseaux Lake and at the head of Short's Creek at the northern end of Okanagan Lake. I examined a specimen taken recently near Penticton where twenty-seven head were counted at one time in the autumn of 1936. It is possible that the Penticton band is the same as that wintering at Vasseaux Lake.

Fragmentary skulls from Dot, in the Nicola Valley, and from Tranquille Creek northwest of Kamloops attest the former presence of sheep in these areas but there are none now in existence on the east side of the Fraser River between Okanagan and Clinton except some introduced bighorns *(canadensis)* at Spences Bridge, Squilax and Adams Lake. Sheep occurred at one time in the Lillooet Range at least as far south as Texas Creek, where in 1938 I picked up skull fragments. None now range south of Lillooet. The Report of the Provincial Game Warden for 1935 records the presence of a band of sixty sheep on Mount McLean just north of Lillooet and another band in the Marble Mountains on the east side of the Fraser River northwest of Clinton. The race is most abundant in the mountains about the headwaters of Yalakom River, Churn Creek, Big Creek, Bridge River and as far west as Chilko Lake. Stray sheep from this area are occasionally seen on the benches bordering the Fraser River opposite Big Bar Creek. As recently as 1931 a small band was

reported to be occupying the bluffs bordering the Fraser River near the mouth of the Chilcotin River.

Washington.—A small band of California bighorn is known to occupy the mountainous district along the Canadian border of Chelan County on what is known as Bauerman Ridge, and in the vicinity of Mount Chopaka. So far as I have been able to determine these are all the sheep still remaining in the state. Until fifteen years or so ago a band existed on Azurite Peak at the junction of Whatcom, Okanagan and Skagit counties. Dr. R. M. Bond writes me under date of December 29, 1938, that Mr. Phil Linville, of Ephrata, Washington, and Mr. Earl Simmons of Quincy, Washington, have some bighorn skulls from Grant and Douglas counties where the sheep are now extinct.

An interesting record of the former occurrence of sheep almost on the Canadian Boundary line in northeastern Washington is provided by N. C. Linsley (1889:227-228). He spent the winter of 1888-89 on the Pend d'Oreille River about twenty miles up from its mouth. In this neighborhood three mountain sheep were killed and it was stated that there were a good many sheep but they were in such rough country as to make hunting difficult.

Oregon.—This race, formerly inhabiting most of the lava beds, buttes and cliffs of eastern Oregon is now thought to be extinct within the state unless the fifty or so individuals reported as still in existence in the Wallowa National Forest prove to belong to this race rather than to *canadensis*. The story of the extinction and the details of former range and abundance are well told by Bailey (1936:64-70.)

California.—Formerly occupied the lava bed region of northeastern California in Modoc, Lassen and Siskiyou counties. Sheep probably of this race occurred on Mount Shasta and on other mountains in the vicinity including Scott Mountain, Goose Nest Mountain, Bogus Mountain and the Siskiyous (Merriam, Journ. Mamm. 2:239). Bighorn are reported south at least to Observation Peak in eastern Lassen County (Grinnell, Dixon and Linsdale, 1930:577). Wistar in his journal (1914:113) records shooting two sheep on the east side of Donner Pass [Nevada County]. There is therefore every reason to believe that sheep ranged almost continuously along the entire eastern slope of the Sierras in California.

Further south sheep occurred formerly north at least to the vicinity of Sonora Peak in Alpine County and from there south to the vicinity of Tejon Pass, Tulare County. Now exists (Grinnell 1933:210) only from vicinity of Mammoth Pass, Mono County, south to vicinity of Olancha Peak and the Kaweah Peaks, Tulare County. A specimen in the Museum of Vertebrate Zoology taken near Glennville, Kern County, in 1936 is the grayest bighorn I have examined. In color it is almost indistinguishable from certain Yukon specimens of *O. dalli*.

Nevada.—In 1905 L. Bilding of Stockton, California, reported to Dr. C. Hart Merriam that W. B. Sampson had a specimen of mountain sheep from Division Peak and that W. H. Lyons had one from Granite Peak both localities in northwest Nevada. Wistar (1914:109) when on the Truckee River in

what is now northwest Nevada in August 1849 records the abundance of bighorn and states that "Bighorn are constantly in sight on all commanding points. . . ."

Sheep are not now present in this part of Nevada. The sheep in the areas mentioned above would almost undoubtedly prove referable to the California bighorn.

*Specimens examined.*—Total number 133.*

BRITISH COLUMBIA: Similkameen 18; 120 miles northwest of Lillooet 11; Churn Creek 11; Lillooet 31'7; Vasseaux Lake 23'7; Juniper Mountain, Ashnola Creek 43; Ashnola Range, 18 miles west of Similkameen River 13; Tranquille Creek 17; Dot 17; Shorts Creek, Okanagan Lake 17; Texas Creek 17.

WASHINGTON: North fork Methow River 18, Mount Chopaka 31'11; Wenaha Mountain 11; Stehekin 11; Cable Mountain, Wenatchee Mountains 21; Naches River, north of Yakima 11; Upper Tucannon River (not identifiable); 1; Hellgate District, southeast Ferry County (not identifiable).

OREGON: Maupin 11; Nigger Rock Canyon 11; Pine Mountain 11; Rock Creek 21; Shaniko 11; Sheepshead Mountains 11; Steen Mountains 5[1] Tule Lake 1[1]; East slope Warner Mountains 21; Watson 21; Euchre Butte 11; Blue Mountains 1[1]; Crowley 11; Fossil 21; Hampton 31; Jordan Creek 2[1]; Mahogany Mountain 1[1].

CALIFORNIA: Tin Mountain 31; Tule Lake 31'4; Lava Caves 41; Sierra Nevada 11; Mount Baxter 11; Banner Peak 11; Warren Peak, Warner Mountains 14; between Lookout and Goose Lake 14; Glass Mountain 14; Glenville 14; Muriel Lake 14; south fork Cartridge Creek (trib. of Kings River) 14; east slope Mount Baxter 44; Parsons Peak, Yosemite Park 24; Sonora Peak 14; Crescent Lake 14. In the Museum of Vertebrate Zoology are weathered horns and, or. cores from the following localities in Inyo County, California. In view of the intermediate geographic position of these localities and studies of identifiable specimens it is probable that the sheep represented by these fragments had characters intermediate between those of *californiana* and *nelsoni*. Whitney Pass 1; northeast slopes of Mount Goddard 1; Mount Tyndall 1; Sawmill Creek, on Piedmont slope 1; Alabama Hills 2; Lone Pine Trail (E. of Mount Whitney) 1; Muriel Lake 1; Pinyon Creek 1; West of Temple Crag, Mount Alice 1; Big Pine 2.

NEVADA: Little High Rock Canyon 14; Pahrum Peak 14.

### *Ovis canadensis nelsoni* Merriam—NELSON BIGHORN

*Ovis nelsoni* Merriam, Proc. Biol. Soc. Wash. **11**, 1897: 218; Hornaday, 5th Rep. New York Zool. Soc. (1900), 1901: 120; Stone and Cram, Amer. Mammals 1903: 64; Osgood, N. Amer. Fauna, No. 30, 1909: 51; Lyon & Osgood, U.S. Nat. Mus. Bull. 62, 1909: 11; Miller, Bull. U.S. Nat. Mus. No. 128, 1923: 497.

*Ovis canadensis nelsoni*, Lydekker, Wild Oxen, Sheep and Goats, 1898: 208; Great and Small Game of Europe, etc. 1901: 10; The Sheep and Its Cousins, 1912: 290; Stephens, Calif. Mammals, 1906: 58; Mearns, Mamm. U. S. and Mex. Bound. Surv. **1**, 1907: 245; Lydekker, Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 114; Grinnell and Swarth, U. C. Publ. Zool **10**, No. 10, 1913: 322; Grinnell, U. C. Publ. Zool **12**, No. 4, 1914: 218; Millais, The Gun at Home and Abroad, **4**, 1915: 323; Seton, Lives of Game Animals, **3**, 1927: 522; Miller, Calif. Fish and Game **13**, No. 1, 1927: 67; Anthony, Field Book of N. A. Mamm. 1928: 545; Ober, Calif. Fish and Game, **17**, No. 1, 1931: 27; Burt, Trans. San Diego Soc. Nat. Hist. **7**, No. 36, 1934: 424; Grinnell, U. C. Publ. Zool. 40, No. 2, 1933: 210; Proc. Calif. Acad. Sci. **23**, No. 9, 1937: 168; Dixon and Sumner, Calif. Fish and Game, **25**, No. 2, 1939: 72.

* For key to institutions referred to by index figures see page 541.

*Ovis cervina nelsoni*, Elliot, Zool. Publ. Field Mus. **2**, 1901: 46; Zool. Publ. Field Mus. **6**, 1905: 54. Allen, Bull. Amer. Mus. Nat. Hist. **31**, 1912: 26.

*Ovis canadensis* subs.? Borrell and Ellis, Journ. Mammal. **15**, No. 1, 1934: 43.

*Type.*—In U. S. Nat. Mus., skin and skull Biological Survey Collection, 28383/40487 adult female; collected June 4, 1891, by E. W. Wilson in Grapevine Mountains on boundary between Inyo County, California, and Esmeralda County, Nevada, just south of latitude 37. Original Number 942.

*Range.*—California, south and east of the Sierras and eastward locally through the desert ranges of Nevada.

*Diagnosis.*—A sheep of the same general appearance as *canadensis* but paler in color with more slender horns, longer ears and heavier molar teeth.

*Measurements.*—The six-year old type female measured as follows: Total length 1280 mm., tail vertebrae 100 mm., hind foot 360 mm., height at shoulder 830 mm. Adult male San Diego County, California, 1600, 127, 400; male, same locality 1390, 122, 400; male, Santa Rosa Mountains, Riverside County, Calif., 1460, 111, 410; female, same locality 1245, 105, 365; another female 1370-120-365. Ober (1931:36) gives the average dressed weight of a California ram as about 140 pounds.

*Horns.*—More slender than in *canadensis* and paler than in that race; closely curled but with tips strongly everted, much more so than in *canadensis*. Smaller than in *cremnobates* and more divergent. Horns of females larger than in *californiana* and *canadensis*. Smaller than *gaillardi* and *cremnobates*.

*Comparisons.*—Averaging paler than *canadensis* but light extremes of that race are indistinguishable from certain specimens of *nelsoni*. Further distinguished from the northern race by smaller size, larger ears and possibly by somewhat smaller rump patch.

Comparison of specimens of *nelsoni* with comparable material of *mexicana* reveals little significant external difference. There is possibly a darker body color in fresh pelage, the dorsal stripe tends to be more pronounced and the

TABLE 20.—Cranial measurements of *Ovis c. nelsoni* males.

| *Variate | N | M | R | σ | σ′ | v |
|---|---|---|---|---|---|---|
| Basilar length | 8 | 262±3.55 | 250–275 | 9.41±2.35 | 10.05 | 3.59± .89 |
| Nasal length | 10 | 117±1.89 | 106–123 | 5.40±1.27 | 5.67 | 4.85±1.09 |
| Nasal width | 9 | 53±2.20 | 42–61 | 5.85±1.47 | 6.22 | 10.08±2.61 |
| Orbital width | 11 | 119±1.85 | 109–127 | 5.84±1.25 | 6.13 | 4.90±1.05 |
| Zygomatic width | 11 | 130±1.75 | 125–135 | 5.45±1.17 | 5.73 | 4.20± .895 |
| Maxillary width | 11 | 93±1.25 | 84–98 | 3.96± .845 | 4.15 | 4.26± .910 |
| Mastoid width | 11 | 90± .99 | 84–95 | 3.12± .667 | 3.28 | 3.46± .735 |
| Palatal breadth at M3 | 11 | 55± .895 | 52–61 | 2.83± .60 | 2.96 | 5.15±1.09 |
| Palatal br. at $Pm^2$ | 10 | 33± .745 | 31–37 | 2.24± .50 | 2.36 | 6.78±1.51 |
| Upper molar series | 11 | 86± .883 | 81–90 | 2.79± .595 | 2.92 | 3.25± .680 |
| Prealveolar length | 6 | 81±1.87 | 77–87 | 4.20±1.21 | 4.57 | 5.16±1.49 |
| Post dental length | 6 | 90±3.65 | 79–103 | 7.48±2.36 | 8.20 | 8.30±2.40 |

* For explanation of symbols see page 516.

TABLE 21.—Cranial measurements of *O. c. nelsoni* females.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 5 | 228±1.13 | 226–232 | 2.24± .70 | 2.50 | .975±3.09 |
| Nasal length | 6 | 91±2.18 | 86–100 | 4.88±1.41 | 5.35 | 5.35 ±1.54 |
| Nasal width | 6 | 34±1.44 | 29–38 | 3.24± .93 | 3.54 | 9.50 ±2.75 |
| Orbital width | 6 | 102±1.44 | 97–104 | 3.24± .935 | 3.54 | 3.16 ± .915 |
| Zygomatic width | 6 | 112±1.35 | 110–119 | 3.01± .875 | 3.31 | 2.69 ± .780 |
| Maxillary width | 6 | 81± .94 | 79–84 | 1.29± .605 | 2.10 | 2.66 ± .770 |
| Mastoid width | 6 | 73± .71 | 71–76 | 1.58± .457 | 1.73 | 2.16 ±6.23 |
| Palatal breadth at M3 | 6 | 52± .91 | 48–54 | 2.12± .61 | 2.32 | 4.07 ±1.17 |
| Palatal br. at $Pm^2$ | 6 | 28± .91 | 24–31 | 2.12± .61 | 2.32 | 7.56 ±2.18 |
| Molar series | 6 | 82±1.27 | 77–85 | 2.85± .83 | 3.13 | 3.48 ±1.01 |
| Prealveolar length | 5 | 71±1.22 | 69–74 | 2.18± .77 | 2.45 | 3.42 ±1.08 |
| Post dental length | 6 | 75±1.31 | 72–79 | 2.92± .845 | 3.20 | 3.79 ±1.12 |

tail stripe complete on the former. *O. c. nelsoni* in fresh pelage is somewhat darker than corresponding specimens of *cremnobates*.

*Cranial comparisons.*—The differences between *nelsoni* males and females and those of *californiana* and *canadensis* have been discussed in the treatment of those races.

In the following comparisons between females of *cremnobates* and *nelsoni* it should be borne in mind that though both series are composed of fully adult animals, the average age of the *cremnobates* series exceeds that of the *nelsoni* series. Though I have not been able, through lack of appropriate material, to study the changes in the female skull after adulthood is reached the data derived from the somewhat inadequate series of male *canadensis* (see p. 512) suggests that age variation in the skull during this portion of the animals life is not great. Nevertheless this difference in mean age of the two series of females may be contributing to the results, which should be regarded accordingly.

In every measured feature female *nelsoni* average smaller than *cremnobates* but in only a few of these is the observed difference significant. Thus in basilar length, nasal length, maxillary width, mastoid width, diastema and post-palate *nelsoni* is smaller to a significant degree (P=less than .01). Width of palate at $Pm^2$ (P between .01 and .02) and zygomatic width, with the same value of P may also prove to be significant when larger series become available. In the series compared *nelsoni* appears to have the upper tooth rows more inclined toward each other anteriorly, but range of variation renders this difference invalid in such small numbers of individuals. The same is true of the ratio length of nasals to breadth of nasals in which by inspection the nasals of *nelsoni* appear to be relatively broader, as they are significantly shorter but of almost the same combined breadth.

In the series of *nelsoni* and *cremnobates* males the latter exceed the former in all measurements but width of nasals, mastoid width, in which *nelsoni* is larger, and width of post-palate in which the means of the two series are identical.

The palate at $M^3$ and at $Pm^2$ are both significantly narrower in *nelsoni*, and the maxillary breadth (.02) and nasal length (P=.05) may prove to be so when larger numbers are available.

The mastoid region in *nelsoni* is significantly broader, in relation to the basilar length than is the case with *cremnobates*. In the former this ratio averages 35 per cent (33-37) and in the latter 32 per cent (31-34).

Females of *nelsoni* and of sheep from southwestern Arizona prove to be almost indistinguishable. Though the measured series of the former average slightly smaller in almost all measurements th· differences are too small to be valid. Only the prealveolar length is significantly greater in the latter, while the upper tooth row (P=.06) and the ratio between breadth of palate at $M^3$ and $Pm^2$ (P=about .04) may prove to be so with the collection of further specimens. This ratio averages 54 per cent (51-60) in *nelsoni*, 60 per cent (58-66) in Arizona specimens indicating more nearly parallel tooth rows in the latter.

I have been unable to find a single skull character of undoubted validity to distinguish between males of these two populations. Width of palate at $M^3$ (P=about .04) and length of upper tooth row (P=.05) may possibly prove significant when more material is obtained. In both these, the Arizona specimens exceed *nelsoni*. It should be pointed out here that in every characteristic mentioned above by which the sheep of southwestern Arizona differs from the population representing *nelsoni* it approaches the characters of *mexicana*.

In view of the highly indeterminate nature of the relationship demonstrated between *nelsoni* and the population currently recognized as *gaillardi* which has been commented on further in the treatment of *mexicana* I have made critical comparison between the sheep of southeastern California and adjacent Nevada, and those of Chihuahua Province, Mexico and adjacent Texas, (i.e. *nelsoni* and *mexicanus*).

By inspection *mexicanus* ewes have skulls larger than *nelsoni* ewes in all measured details.

In the following details the observed differences prove significant (P=.01 or less), nasal width, maxillary width, mastoid width, length of upper tooth row, and diastema. Nasal length (P=less than .02) and width of palate at Pm (P=.02) will bear further scrutiny. Differences displayed by width of orbit (P between .1 and .05), basilar length, width of palate at $M^3$ and post dental length all with values of P=.1 or greater may prove significant when if ever, very large series are available. The ratio, width of palate at $M^3$ to width of palate at $Pm^2$ averages 60 per cent in *mexicanus* ewes.

The series of adult male *mexicanus* average slightly smaller than the corresponding measurements of *nelsoni* except in the two measurements of width of palate at $M^3$ and $Pm^2$ and in length of upper and lower tooth rows. In these features *nelsoni* is somewhat the smaller. In no instance however are the small observed differences significant. That between the mastoid widths (P=.04) comes closest to being so.

*Status.*—Nevada: This race is stated by Burt (1934:424) to be common in the Sheep Mountains but almost if not completely exterminated in the Charleston Mountains. Linsdale (1938:199) reports bighorn as probably still present in the Toyabe Mountains at least as recently as 1931. So far as known still present in the Grapevine Mountains. Dr. E. R. Hall of the Museum of Vertebrate Zoology in a letter dated October 16, 1939, states that sheep are still abundant in the southern third of the state but that he has no reliable report of sheep now occurring in Nevada north of the 39th Parallel of latitude. He has satisfactory evidence of their presence in Sheep Mountains, Clark County, White Pine Mountains, Quinn Canyon Mountains. Eleven years ago some were present on Lone Mountain, twelve miles east of Tonopah. In 1928 he saw fresh signs on the Silver Peak Range, Esmeralda County, and they are still reported to be present in the Monte Cristo Range of the same county. A field party from the Museum in the summer of 1939 failed to find evidence of the continuing presence of sheep on the Snake Range twelve miles west of the Utah border on the 39th parallel, but found old skulls none of which provide measurements from which racial allocation can be made. The subspecific affinities of the sheep formerly inhabiting the northern part of the state and at present found in the White Pine Mountains can only be guessed at until such time as suitable material is obtained for study.

California.—Grinnell (1937:169) found the Nelson Bighorn to be present in the Death Valley region in numbers equal to the carrying capacity of the range. They were stated "to occur on all the desert ranges around Death Valley, the greatest numbers on the Panamint Mountains."

Ober (1931:31) writes "Mount Montgomery, in the White Mountains (Inyo Co.) forms the northern boundary of the desert mountain sheep. This variety can be found here and there southward throughout the White Mountains. They may almost always be found around White Mountain Peak and its immediate vicinity to the north, and Deep Springs, Homestake Canyon, Pecite Monument, Beverage Mountains, Wacaha Mountain, Lead Canyon, head of Willow Creek, Saline Valley Mountains and on down as far as Cerro Gordo to the south. They range to the east in nearly every mountain range throughout the Death Valley Section to the Nevada line. In southern California, Mount Baldy and Cucamonga Peak have small remnant herds and Old Grayback Mountain, it may be said, contains just a small number over the remnant stage. The San Jacinto Mountains contain sheep west of Palm Springs and around what is known as Borago Valley sections and to the south sparingly in the range to Campo, on the Mexican line. The mountains to the east and north of Imperial Valley, together with those of Riverside and San Bernardino counties, east to the Colorado River contain mountain sheep in the remote and extreme sections. San Bernardino county has the distinction of having, in the mountains to the north and east, the second largest number of mountain sheep in California." The same author estimated that at that time (1931) the total number of mountain sheep of all races in California did not exceed three thousand head.

The absence of identifiable material from northern Nevada renders it impossible to demarcate the original limit of *nelsoni* in that state or to study

the extent of the intergradation area along the east slope of the Sierra Nevada. Specimens from the Sierra side of Owens Valley and from the Inyo Mountain side of the same valley in California indicate a complete blending of the characters of *nelsoni* and *californiana* in that area. A small series of these intergrades were the basis for the description of *sierrae* (Grinnell 1912).

Statements by Fremont (1845:216) concerning the abundance of sheep in Pyramid Lake area of Nevada and the characteristics exhibited by certain specimens from the vicinity of Yosemite Park suggest that extensive intergradation between these two races formerly took place along the eastern foothills of the Sierra Nevada.

Similarly the absence of specimens leaves a blank in our data concerning the northern and eastern limits of distribution of *nelsoni*.

The sheep of the Grand Canyon, Arizona, agree better with *nelsoni* than with *canadensis* as far as can be judged from the material I have studied.

McKee (1934:298) states that sheep are of not uncommon occurrence along the entire Grand Canyon on the south side of the Colorado River. North of the river in the Grand Canyon he could find not a single authentic record of a mountain sheep east of Kanab Canyon. In Kanab Canyon however, and farther west in Toroweap, sheep were reported fairly numerous by Thompson (1933:167).

To the west, in the San Jacinto and San Bernardino mountains of California the sheep are larger than they are in the Great Basin area with slightly larger skulls, broader across the zygomata, and with heavier tooth rows. In as much as these are among the differences separating the population of northern Lower California from that of the Great Basin and Death Valley regions it is perhaps justifiable to regard these larger sheep of the San Bernardinos as approaching *cremnobates*. An old male No. 452 in a series from "Riverside Co." in the California Academy of Sciences is essentially indistinguishable from similarly aged rams from Lower California. On the other hand an old male from Julian, San Diego Co., California, while atypical is apparently closer to the mean of *nelsoni*.

Bighorn formerly extended as far westward in southern California as the Cuyama Valley. A note in the files of Dr. C. Hart Merriam mentions a letter written by E. A. Goldman on August 3, 1916, stating that he had been told that bighorn were not long extinct on Caliente Peak, San Luis Obispo County, California.

*Specimens examined*.—Total number 122. Unless otherwise indicated specimens are in Museum of Vertebrate Zoology, Berkeley, California.†

CALIFORNIA: Inyo County: Funeral Range, Death Valley, 1; Telescope Peak, 1; Bad Water, Death Valley, 1; Kelley's Wells, Armargosa River 1; Hananpah Canyon, Panamint Mountains 1; Funeral Mountains near Furnace Creek Ranch 16; West slope of Inyo Range 11; Grapevine Mountains 71; Panamint Mountains 11; Tin Mountains 410; Dry Mountain 110; Big Pine 210.—Mono County: West slope Sheep Mountain, White Mountains 1; McAfee Meadow 1.—Imperial County: Picacho (20 miles west) 6; Palo Verde 1.—Santa Barbara County: Cuyama Plain, base White Mountain 110.—San Luis Obispo County; Caliente Peak, Cuyama Valley 1.—San

Bernardino County: San Gorgonio Peak, San Bernardino Mountains 1; Crest of Bullion Mountains, 20 miles north of 29 Palms 1; Rattlesnake Canyon, Little San Bernardino Mountains 1; northwest end of Sheep Hole Mountains 1; West end of Granite Mountains, Mojave Desert 1; Old Woman Mountains 2; 7½ miles northeast of Chubbuck, Old Woman Mountains 2; Mitchell's Caverns, Providence Mountains 2 and 14; Providence Mountains 21; Ontario Peak, San Bernardino Mountains 11; (approaching *cremnobates.*)—Los Angeles County: Head of Rock Creek, San Gabriel Mountains 2.—Riverside County: 15 miles east north east of Salton 1; Canyon Springs, Chuckwalla Mountains 1; Santa Rosa Mountains 2; Cottonwood Spring 110; Unstated 210.

NEVADA: Esmeralda County: ½ mile northeast of Cane Spring 2; Silver Peak Mountains 41; Grapevine Mountains 41.—Nye County: Mount Jefferson, Toquima Range 1; 6 miles northeast of Italian Springs, Quinn Canyon Mountains 14; Toyabe Mountains 41.—Clark County:? Colorado River, 14 miles east of Searchlight 1; 4 miles east of Boulder City, Sheep Mountains 11; Charleston Mountains 11; Colorado River 11.—Mineral County: Middle Fork Cat Creek 1.—Lander County: 28 miles north of Austin 1; Austin 11.—White Pine County: Baker Creek 24'1; Hendry Creek 1½ miles east of Mount Moriah 14; Clive River, Shell Creek Range 14.—Humboldt County: Jackson Mountains 21; Monte Cristo Mountains 21; Coaldale 31; Colorado 11; St. Mary's Lake 11; Black Mountains 11.

ARIZONA: *Cataract Canyon 31, *Grand Canyon 2.

### *Ovis canadensis cremnobates* Elliot—PENINSULA BIGHORN

*Ovis cervina cremnobates* Elliot, Zool. Publ. Field Mus. **3**, 1903: 239; Zool. Publ. Field Mus. **5**, 1904: 84; Zool. Publ. Field Mus. **6**, 1905: 54; Allen, Bull. Amer. Mus. Nat. Hist. 31, 1912: 27.

*Ovis canadensis cremnobates*, Lydekker, The Sheep and Its Cousins. 1912: 292; Cat. Ung. Mamm. Brit. Mus. **1**, 1913: 115, Miller, Bull. U.S. Nat. Mus. No. 128, 1923: 496; Seton, Lives **3**, 1927: 523; Grinnell, U. C. Publ. Zool. **40**, No. 2, 1933: 211.

*Type.*—In Field Columbian Museum; female sub-adult skin and skull Number 10943; taken at Mattomi, Sierra San Pedro Martir, Lower California, June 21, 1902, by Edmund Heller. Nasals and incisors missing when examined in 1937, otherwise in good condition.

*Range.*—Extreme southern California and northern Lower California for an undetermined distance southward.

*Diagnosis.*—A very light colored sheep, perhaps the palest of the species with dark legs, relatively heavy horns in both sexes and large, heavy skulls with long narrow nasals and long molar series.

*Measurements.*—Four adult females average as follows: Total length 1380 mm. (1166-1450); tail 111 (102-120); hind foot 321.5 (276 375); ear from crown 114 in one individual. Average of height of ear from notch in five individuals (measured dry), 98.4 mm. (95-105). A five-year old ram measured total length 1540; tail 250; hind foot 408.

*Color.*—Palest of any race with possible exception of *mexicana.* October specimens have the sides and backs about Wood Brown darkening along the mid-dorsal region into a pronounced line from nape to tail. Color of legs

* Indicates one or more specimens with intermediate characters.

* For key to institutions referred to by index figures see page 541.

approaching Natal Brown. Muzzle pale brownish in some specimens white in others. Much white on underparts and completely down inner surfaces of fore and hind legs. Certain individuals have a white patch on the chin, another on the throat.

*Horns.*—Pale in color, moderately divergent with very heavy bases. Females with (except for *weemsi*) the longest and heaviest horns of the species.

*Comparison.*—*O. c. cremnobates* differs from California specimens of *nelsoni* in slightly paler average coloration and possibly in having somewhat longer ears. From *weemsi*, the only other race with adjoining range *cremnobates* can be distinguished by its lighter colors in corresponding pelages and by certain cranial charatcers.

A series of July and August specimens from the vicinity of St. Louis, Lower California, (Amer. Mus. Numbers 24234-24238) average somewhat redder than specimens from just south of the international boundary below Tucson, Arizona. The only pronounced color difference between these two populations representing *cremnobates* and *mexicana* respectively is in the legs, these are consistently lighter in color in the Lower California specimens, being between Verona and Mikado brown at their darkest rather than between Verona and Warm Sepia. The large ram in this series has no white on the underparts but is whitish on back of legs, rump and tip of nose. Others have the abdomen white. Tail line is complete in all cases. The faces of all the St. Louis adults have a rusty wash apparently not the result of staining. This is very much the color of the legs and quite distinct from the Avellaneous to Wood Brown facial coloring of the above mentioned specimens of *mexicana*.

Cranially *cremnobates* and *weemsi* are very similar. As regards the measurements taken females of the two races are indistinguishable. Males of *cremnobates* however have the palatal breadth at $M^3$ significantly less, and the post-dental length also significantly less. The narrow palate posteriorly, accompanied as it is by relatively wide palate anteriorly gives the tooth rows of *weemsi* the appearance of being more nearly parallel than is the case in *cremnobates*. The mean of the ratio palatal width at $M^3$ to palatal width at $Pm^2$ is

TABLE 22.—Cranial measurements of *cremnobates* males.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 7 | 271±2.83 | 260–280 | 6.95±2.00 | 7.5 | 2.56± .740 |
| Nasal length | 6 | 124±2.71 | 116–134 | 6.65±1.92 | 7.29 | 5.35±1.54 |
| Nasal width | 7 | 53± .925 | 50–56 | 2.26± .653 | 2.45 | 4.28±1.27 |
| Orbital width | 7 | 124±1.36 | 118–129 | 3.29± .95 | 3.56 | 2.65± .765 |
| Zygomatic width | 7 | 131±1.37 | 124–135 | 3.36± .966 | 3.63 | 2.56± .739 |
| Maxillary width | 7 | 98±1.18 | 94–102 | 2.90± .835 | 3.12 | 2.95± .835 |
| Mastoid width | 6 | 88±1.69 | 87–93 | 3.95±1.14 | 4.34 | 4.50±1.30 |
| Palatal breadth at $M^3$ | 6 | 60± .905 | 57–62 | 2.12± .612 | 2.22 | 3.52±1.02 |
| Palatal br. at $Pm^2$ | 6 | 37± .835 | 34–39 | 1.96± .565 | 2.12 | 5.27±1.52 |
| Molar series | 6 | 88±1.63 | 89–91 | 3.83±1.10 | 4.20 | 4.35±1.25 |
| Prealveolar length | 5 | 85±1.34 | 82–90 | 2.68± .849 | 3.00 | 3.53±1.20 |
| Post dental length | 5 | 91± .835 | 89–93 | 1.67± .53 | 1.87 | 1.84± .582 |

* For explanation of symbols see page 516.

TABLE 23.—Cranial measurements of *O. c. cremnobates* females.

| *Variate | N | M | R | σ | σ′ | V |
|---|---|---|---|---|---|---|
| Basilar length | 3 | 250±4.10 | 241–256 | 5.80±2.36 | 7.10 | 2.32± .945 |
| Nasal length | 5 | 108±1.84 | 104–113 | 3.29±1.16 | 3.68 | 3.40±1.70 |
| Nasal width | 5 | 36±1.60 | 30–39 | 3.19±1.01 | 3.56 | 8.85±2.81 |
| Orbital width | 5 | 103±2.60 | 98–109 | 5.21±1.65 | 5.82 | 5.05±1.60 |
| Zygomatic width | 5 | 118±1.37 | 114–122 | 2.75± .870 | 3.08 | 2.34± .737 |
| Maxillary width | 5 | 89±1.53 | 87–93 | 3.07± .960 | 3.42 | 3.42±1.08 |
| Mastoid width | 4 | 79±1.12 | 77–82 | 1.94± .68 | 2.23 | 2.44± .865 |
| Palatal breadth at M3 | 5 | 55± .805 | 53–57 | 1.61± .510 | 1.80 | 2.84± .930 |
| Palatal br. at $Pm^2$ | 5 | 32±1.30 | 28–35 | 2.60± .820 | 2.90 | 8.10±2.56 |
| Upper molar series | 4 | 86± .95 | 84–89 | 1.89± .60 | 2.12 | 2.20± .695 |
| Prealveolar length | 5 | 78±1.77 | 74–84 | 3.55±1.12 | 3.96 | 4.55±1.44 |
| Post dental length | 4 | 82±1.28 | 78–85 | 2.57± .810 | 2.86 | 3.13± .990 |

69 per cent in *weemsi*, 62 per cent in *cremnobates*. However individual variation is so high that the difference is not of significance on the basis of present material.

Other differences in proportion of the skulls can be derived from comparison of various cranial measurements but none of them is valid in such small series. The development of lateral wings on the median palatal arm of the premaxillae is carried to a greater degree of development in the four specimens of *weemsi* than in any *cremnobates* examined. A full discussion of the demonstrable cranial differences between *cremnobates* and *nelsoni* will be found in the treatment of the latter race.

*Remarks.*—A specimen from Julian, California, is intermediate between *nelsoni* and *cremnobates*, closer to *nelsoni* in length of nasals but closer to the southern races as regards width of rostrum and basilar length. An adult male from "Riverside County" California in the California Academy of Sciences is indistinguishable from Lower California bighorn except that the horns are somewhat less massive than is usual in adult rams from the latter area.

Specimens from San Jacinto and San Bernardino ranges examined by me on the average seem to me to resemble *nelsoni* somewhat more closely than they do *cremnobates* in the aggregate of characters. However Grinnell (1933) has with probably equal propriety chosen to regard them as closer to *cremnobates*. For purposes of museum cataloguing it matters little to which race they are assigned. On point of fact they are intermediate and typical of neither.

I have been unable to obtain any accurate information on the present distribution and status of bighorn in Lower California.

*Specimens examined.*—Total number 59.†

Southeastern Sierra San Martir 14; Cocopah Mountains 124'1'9; 20 miles west of Fort St. Louis 58; 40 miles northwest of Fort San Luis 19; 8 miles northwest of Fort San Luis 19; Laguna Hanson 21; Aroyo Grande 21; San Felipe Bay 11; Camp Mattomi 41; Mattomi, Sierra San Pedro Martir 235; Providencia 15.

CALIFORNIA: Chuckwalla Mountains 54, Julian 24, almost exactly intermediate between *nelsoni* and *cremnobates*.

† For key to institutions referred to by index figures see page 541.

*Ovis canadensis weemsi* Goldman—WEEMS BIGHORN

*Ovis canadensis weemsi* Goldman, Proc. Biol. Soc. Wash. **50**:29-32, 1937.

*Type.*—In U. S. Nat. Mus. Biological Survey Collection. No. 261696, adult female skin and skull. Taken at Conjon de Tecomaja, Sierra de la Giganta, about thirty miles south of Cerro de la Giganta, southern Lower California, altitude 2000 feet. Collected April 13, 1936, by F. C. Weems.

*Range.*—Sierra de la Giganta, southern Lower California and northward grading toward *cremnobates* in the Sierra de San Borjas in the central part of the peninsula (Goldman: idem).

*Diagnosis.*—Size much as in other desert races, color dark, pelage short, premaxillae broad and with pronounced lateral ridges on the palatal portions, nasals broad, horns particularly in the females remarkably long and slender.

*Measurements.*—An adult male from near Calmalli: Total length 1626 mm.; height at shoulder 1029 mm.; girth of chest 1006 mm. Adult female (type); Total length 1887, tail 90, hind foot 400 mm. Young adult female

TABLE 24.—Cranial measurements of topotypical *O. c. weemsi.*

| Museum Number | Approximate age | Basilar length | Nasal length | Nasal width | Orbital width | Zygomatic width |
|---|---|---|---|---|---|---|
| | | | | | | Males |
| U. S. N. M. 261698 | 6 | 265 | 117 | 53 | 118 | 123 |
| U. S. N. M. 261699 | Very old | | | | 129 | 130 |
| | 4 | 239 | 104 | 38 | 101 | 111 |
| U. S. N. M. 261697 | | | | | | Females |
| U. S. N. M. 261696 | 7 | 261 | 114 | 43 | 113 | 120 |

| Museum number | Maxillary width | Mastoid width | Palatal breadth at M3 | Palatal breadth at Pm2 | Upper molar series | Prealveolar length | Post dental length |
|---|---|---|---|---|---|---|---|
| U. S. N. M. 261698 | 94 | 84 | 54 | 34 | 89 | 85 | 83 |
| U. S. N. M. 261699 | 96 | 96 | 50 | 37 | 92 | | 87 |
| U. S. N. M. 261697 | 83 | 74 | 51 | 30 | 82 | 78 | 78 |
| U. S. N. M. 261696 | 96 | 77 | 57 | 39 | 89 | 83 | 86 |

topotype: Total elngth 1296, tail vertebrae 77, hind foot 375, height at shoulder 775, girth of chest 940.

*Color.*—In fresh pelage very dark on dorsal surface, approaching Mars Brown even darker on mid-dorsal line, tail and outsides of legs; underparts insides of legs and rump patch white, the latter almost divided by the tail stripe; face whitish, ears brownish gray.

*Horns.*—Much as in other desert races of bighorn, closely similar to those of *nelsoni;* the lateral surface of the horn is flatter and the external ridge more prominent in the specimens of *weemsi* examined than in any other race of *O. canadensis*. Horns of the ewes are long, slender and divergent. Longer than in any other race of the genus in North America.

*Comparisons.*—Detailed comparison need only be made with *cremnobates* the race with adjoining range to the north. For such comparisons see under the latter race.

*Specimens examined.*—

Sierra de la Giganta 41; Sierra San Borjas 20 miles north of Calmalli 61 (specimens from the latter locality are intermediate between *weemsi* and *cremnobates*). All specimens in U. S. Nat. Mus. Biol. Surv. Coll.

## Summary

In the course of this study seven hundred and sixty-one specimens of North American mountain sheep have been examined. This material has formed the basis for a study of individual, seasonal, sex, age and geographic variation in the genus.

It is suggested that *Ovis nivicola* of northeastern Asia, and *Ovis dalli* and *Ovis canadensis* of North America had a common ancestor in early Pleistocene or late Pliocene time. That during the Pleistocene sheep stocks survived in northeastern Siberia and Alaska and in western North America south of the ice cap; and that these three stocks thus isolated have evolved into the three species mentioned above. With the disappearance of the ice cap in North America *O. canadensis* has spread northward and *O. dalli* southward. The ranges of the two species have not as yet made contact but in the region of the Peace River, British Columbia are separated by less than one hundred miles.

Secondary sexual variation is pronounced. It is most noticeable in the horns of adults, but occurs in size and shape of skull, degree of ankylosis of skull elements, general body form and in coat color in at least two races. Females are not found to be less variable than males.

There is some evidence that in *Ovis canadensis* as in *Odocoileus* the size difference between males and females is greatest in the northern and least in the southern parts of the range.

Age variation is exhibited in size and form of horns, degree of ankylosis of skull and in certain less important features. Size and form of skull varies little after the age of six years. No age variation in coat color was observed after the lamb coat was shed.

Individual variation is extreme in size and shape of horns and in color of pelage. Adult skulls are remarkably constant as to size and form but dwarfed individuals occur relatively frequently and are represented by five individuals in the collections examined. Two of these have apparently served as types for supposed geographic races.

Ten geographic races are found to be recognizable on the basis of existing specimens.

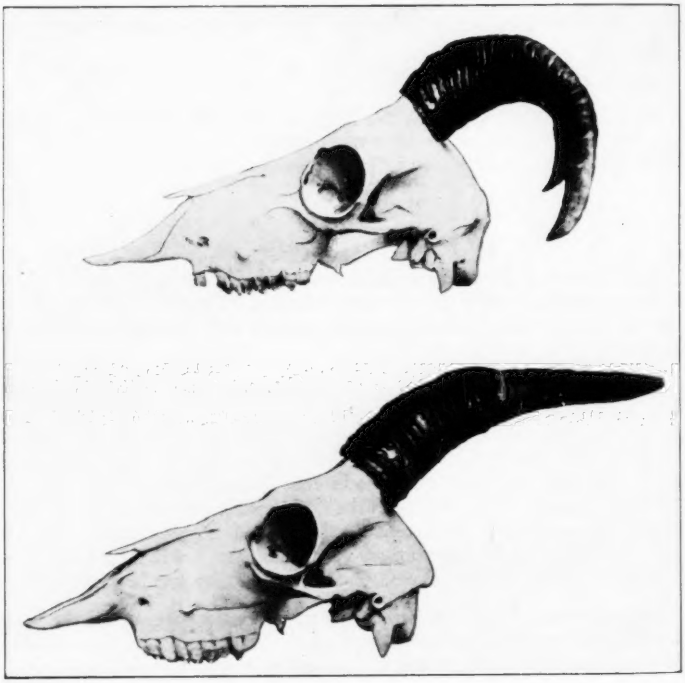


PLATE I

Individual variation in horns of *Ovis canadensis canadensis* females. Upper, M.V.Z. Number 78269, Glacier Park, Montana. Lower, M. V. Z. Number 78268, same locality.

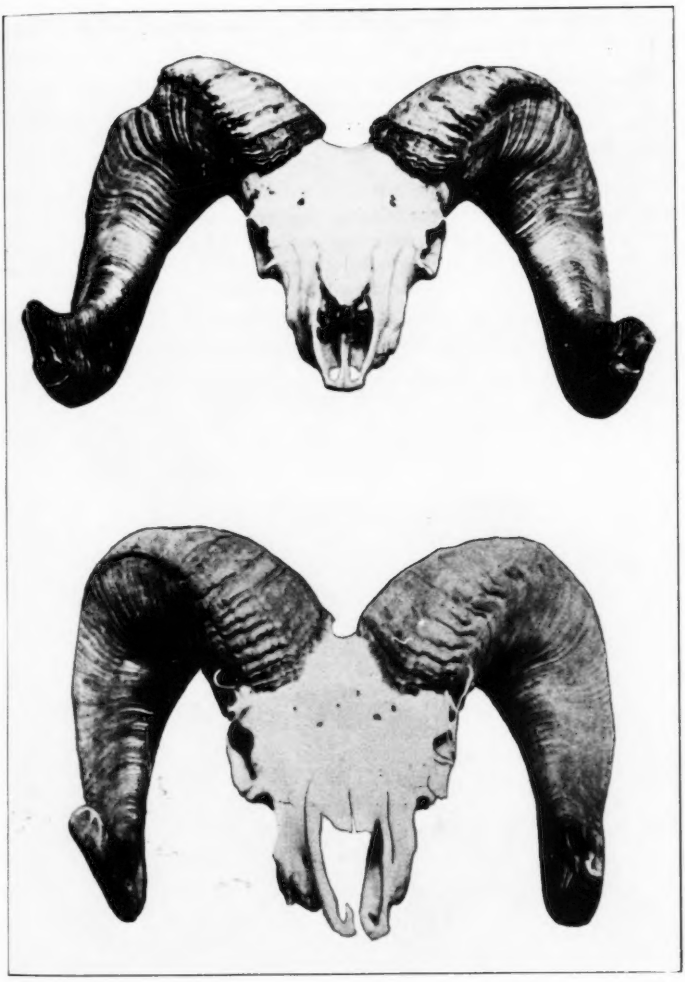


PLATE 2

Individual variations in horns of *Ovis canadensis* males. Upper, M. V. Z. Number 4751, Cocopah Mountains, Lower California, Mexico. Lower, M. V. Z. Number 84250, Tinajas Atlas, Sonora Mexico.

Published and unpublished material has been used in an appraisal of the present distribution and abundance of the various races of mountain sheep inhabiting North America.

*Ovis c. auduboni* is apparently extinct. *O. c. californiana* is represented by a small number of atypical specimens in California, a smaller number in northern Washington, and a fair but largely unappraised population in southwestern British Columbia.

Information regarding the status of *weemsi* and *cremnobates* in Lower California and *mexicana* in the Mexican part of its range, has been unobtainable. All other races, though they have suffered diminution in numbers and even local extermination, still exist in quantities that give hope of restoration up to the carrying capacity of the range now available.

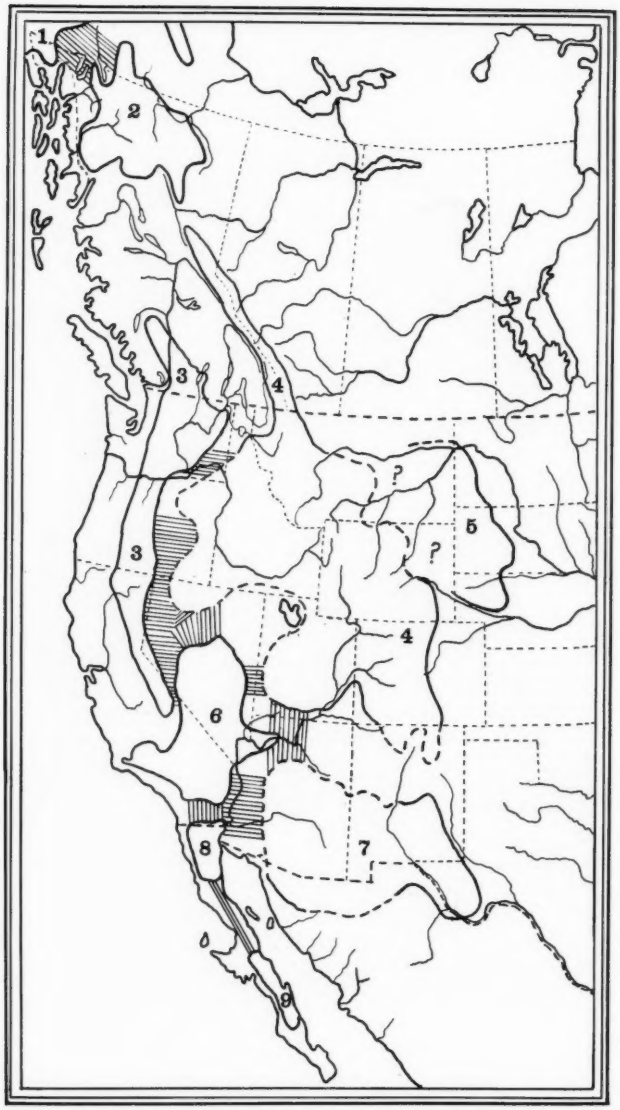
In large parts of eastern British Columbia, western Alberta, Yukon and Alaska sheep still exist under conditions relatively unaltered by man.

PLATE 3

Age variation in skull and horns of *Ovis canadensis* males. Upper left (1), M.V.Z. Number 78263, age approximately 6 months. Lower left (2), M.V.Z. 78264, age approximately 18 months. Upper right (3), M. V. Z. Number 16357, age approximately 4 years. Lower right (4), M. V. Z. Number 78261, age approximately 6 years. 1, 2 and 4, Glacier Park, Montana, 3 Sierra Nevada, Inyo County, California.

PLATE 4

Skulls of *Ovis dalli kenaiensis* (upper) of average type and *Ovis canadensis nelsoni* (lower) of extreme divergent type to illustrate specific differences in horn form other than divergence.




Map illustrating probable distribution of geographic races of native sheep of North America south of the 60th Parallel at the advent of white man, compiled from specimens and published accounts. Broken lines indicate boundaries based on unsatisfactory data. Hatching indicates areas of intergradation. 1, *Ovis dalli dalli*. 2, *O. d. stonei*. 3. *O. canadensis californiana*. 4. *O. c. canadensis*. 5, *O. c. auduboni*. 6. *O. c. nelsoni*. 7. *O. c. mexicana*. 8, *O. c. cremnobates*. 9, *O. c. weemsi*.

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# Comparative Populations of Game, Fur and other Mammals

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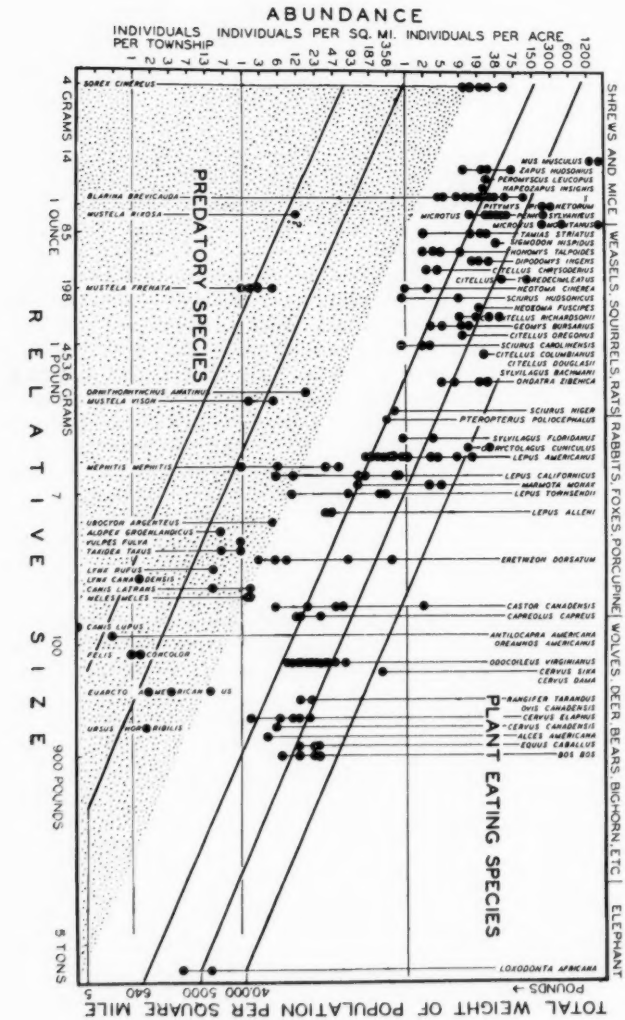
A study of estimates, guesses and actual censuses of mammals published in books, scientific journals, bulletins, etc., shows that few of them were undertaken for the purpose of discovering what the concentration of any one species is on all the territory used by the individuals recorded in the census but excludin that not used in the course of a year. Many censuses are simply counts of herds or other temporary concentrations, the census taker unwittingly overlooking the fact that the particular individuals counted may draw their sustenance and well-being from a far larger area than they appear to be using at the moment. Many other censuses include territory which appears satisfactory to a species but which is actually not part of its habitat. Some are made without comment immediately before a breeding season when the population has reached its low ebb for the year; some, without a statement to that effect, immediately after the breeding season when the population is high; and some at sometime between these periods. Other censuses, for good reasons and limited purposes, deliberately ignore a certain amount of used territory, and aim to find the concentration in a well defined area or vegetation type at a time of the year favorable for a quick count. Thus many censuses appear totally unrelated because blanks of unknown size in the habitat were used when calculations were made or because used habitat is excluded. In other words, few censuses are so made as to reveal economic densities.

The accompanying chart was designed to compare the various kinds of censuses on the assumption that when a large number of studies of any one species is made by many observers, the grouping of observations is likely to reveal economic densities and also show how the many kinds of censuses deviate from those which are specifically and carefully designed to discover economic densities.

Numbers along the left border of the chart indicate the number of individuals per unit of surface area; numbers along the right border, connected with diagonal lines across the chart, indicate the total estimated poundage of each population per square mile; and the numbers at the bottom indicate the approximate size classes of the mammals. The species are arranged in a series from smallest, at the left, to largest, at the right, and common names of some are given at the top border to give a clue to the species treated. Black dots mark the populations of each as recorded in literature and these are connected by lines to the Latin names of the species to which they refer.

Examination of the chart shows that individuals of most plant eating species are at least several hundred times as common in their chosen habitats as are individuals of predatory species of equal size in equally favorable habitats.


ABUNDANCE
INDIVIDUALS PER TOWNSHIP
INDIVIDUALS PER SQ. MI.
INDIVIDUALS PER ACRE
SHREWS AND MICE | WEASELS, SQUIRRELS, RATS | RABBITS, FOXES, PORCUPINE | WOLVES, DEER, BEARS, BIGHORN, ETC | ELEPHANT
PREDATORY SPECIES
PLANT EATING SPECIES
RELATIVE SIZE
4 GRAMS
14
1 OUNCE
85
198
1 POUND
453.6 GRAMS
7
100
900 POUNDS
5 TONS
TOTAL WEIGHT OF POPULATION PER SQUARE MILE
POUNDS
40,000
5000
640
5
SOREX CINEREUS
BLARINA BREVICAUDA
MUSTELA NIVALIS
MUSTELA FRENATA
ORNITHORHYNCHUS ANATINUS
MUSTELA VISON
MEPHITIS MEPHITIS
UROCYON ARGENTEUS
ALOPEX GROENLANDICUS
VULPES FULVA
TAXIDEA TAXUS
LYNX RUFUS
LYNX CANADENSIS
CANIS LATRANS
MELES MELES
CANIS LUPUS
FELIS CONCOLOR
EUARCTOS AMERICANUS
URSUS HORRIBILIS
MUS MUSCULUS
LEPUS HUDSONIUS
PEROMYSCUS LEUCOPUS
NAPEOZAPUS INSIGNIS
PITYMYS PINETORUM
MICROTUS PENNSYLVANICUS
MICROTUS CHRotorrhinus
TAMIAS STRIATUS
SIGMODON HISPIDUS
HOMOMYS TALPOIDES
DIPODOMYS INGENS
CITELLUS CHRYSODEIRUS
CITELLUS TRIDECEMLINEATUS
NEOTOMA CINEREA
SCIURUS HUDSONICUS
NEOTOMA FUSCIPES
CITELLUS RICHARDSONII
GEOMYS BURSARIUS
CITELLUS OREGONUS
SCIURUS CAROLINENSIS
CITELLUS COLUMBIANUS
CITELLUS DOUGLASII
SYLVILAGUS BACHMANI
ONDATRA ZIBETHICA
SCIURUS NIGER
PTEROPTERUS POLIOCEPHALUS
SYLVILAGUS FLORIDANUS
LYNCTOLAGUS CUNICULUS
LEPUS AMERICANUS
LEPUS CALIFORNICUS
MARMOTA MONAX
LEPUS TOWNSENDII
LEPUS ALLENI
ERETHIZON DORSATUM
CASTOR CANADENSIS
CAPREOLUS CAPREUS
ANTILOCAPRA AMERICANA
OREAMNOS AMERICANUS
ODOCOILEUS VIRGINIANUS
CERVUS SIKA
CERVUS DAMA
RANGIFER TARANDUS
OVIS CANADENSIS
CERVUS ELAPHUS
CERVUS CANADENSIS
ALCES AMERICANA
EQUUS CABALLUS
BOS BOS
LOXODONTA AFRICANA

Regardless of the average size of individuals composing a species, the populations are such that the total weight of each herb eating species in the habitat from which it sustains itself, exceeds one pound per acre, or 640 pounds per square mile, while the total weight of each predatory species rarely exceeds 75 pounds per square mile and often does not exceed two pounds.

Any plant eating species does not often exceed 5,000 pounds and rarely exceeds 10,000 pounds per square mile.

The purer the food habit, the wider is the difference in abundance. Populations of omnivorous species are such that they attain weights between those maintained by plant eaters and predators. Insect eating species like mole-shrews, (*Blarina brevicauda* Say), also appear to maintain intermediate population weights.

Seed eating species, like squirrels, appear to maintain lesser population weights than species eating a large proportion of grass and browse. In a study so carefully planned and executed that it showed not only how many essentially seed eating *Peromyscus leucopus* occupied a given area, but also how much of that area they actually inhabited, Burt (1940) found from 3 to 11 of these mice per acre. His maps of home ranges showed that when fewer than 4 mice inhabited one acre, they did not use all of it even during long census periods of from 20 to 49 days.

Even some populations of more than 5 mice apparently did not use all the available habitat. The overlapping home ranges tended to be fairly inflexible during the census periods and the number of mice *per acre of area actually in use* was varied from 4.5 to 11. The total weight of populations per acre of area in use must have been in excess of one fifth of a pound and not much more than half a pound.

If an observer, who is attempting to discover the economic density of any purely plant eating species, finds that the total observed poundage is close to, or less than one pound per acre, he may well revise his methods and be on guard for errors. He may be diluting his census figures by including uninhabited ground in his calculations of density. If his figures approach 5,000 pounds per square mile, he should also proceed with caution. He is either observing a high temporary population, a mere aggregation, or encountering drift into his census area.

If his count of a purely predatory species approaches five pounds to the square mile, he should again proceed with care, even if he is censusing at a time when young of the year swell the population. If the count gives him an estimate below one pound even when the population is at its low annual ebb, he should again be on guard.

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# The Western Burrowing Owl in Clay County, Iowa, in 1938[1]

Thomas G. Scott

While a census of the Northern Plains red fox *(Vulpes regalis)* and the striped skunk *(Mephitis m. avia)* was being taken in Clay County, Iowa, in 1938, three families of the western burrowing owl *(Speotyto cunicularia hypugaea)* were located. Upon occasions throughout the summer opportunity was afforded for additional observation of these owls. Grateful acknowledgement is made for supplementary information contributed by Kate E. LaMar and Margaret Bailey Scott. The data accumulated seem worthy of record.

The general range of the western burrowing owl extends from the "Pacific coast of the United States east to Minnesota, western Iowa, and Louisiana, and from British Columbia and Manitoba, south to Panama; migratory north of Oregon, and northern Kansas. Accidental in Indiana, New York, and Massachusetts" (American Ornithologists' Union, 1931). There are records of the nesting of this subspecies in the following Iowa Counties: Clay County, 1933, Errington and Bennett (1935); Dickinson County, 1921 and 1922, Stephens (1938); Emmett County, 1934, Wolden (1934); Green County, 1928, Du Mont (1932); Palo Alto County, 1933, Errington and Bennett (1935); Plymouth County, no date, Bailey (1918, fig. 93); Sac County, 1916, Bailey (1918); Sioux County, 1902, Anderson (1907), and 1911, Gabrielson (1917); Story County, 1923, Birkeland (1933); and Woodbury County, 1898, Anderson (1907) and 1914, Du Mont (1934). During the summer of 1938 young and adult western burrowing owls were seen at a den in Section 23, Eden Township, Winnebago County (Green, unpublished report). The writer observed a family of these owls near Lester, in Lyon County, on August 11 and 18, 1938. Thus the owls in Clay County appear to be within the eastern fringe of the nesting range.

As previously mentioned, the burrows of the three owl families recorded in Clay County in 1938 were found while taking an inventory of the dens of the red fox and the striped skunk in that County. The method of taking the inventory, as described by Scott and Selko (1939), required collections of data by sample inspection, and this covered one-ninth of the total area of the County. Hence the number of families of burrowing owls in the County may possibly be calculated as 9 times 3, or 27.

No more than two adults were observed in each family throughout the period of rearing. The number of young attaining an age enabling them to

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appear outside the den were as follows: Area I, 6; Area II, 6; and Area III, 7. The owls migrated from their respective areas as follows: Those in Area I, between July 31 and August 4; those in Area II, on July 25 or 26; and all but two of those in Area III, on August 15 or 16. The two remaining on Area III consisted of one adult and one young. The young bird either was defective physically or had difficulty in learning, for it was never seen to fly, and on several occasions the adult struck it as if to encourage it to fly. The adult and youngster were still at the den on September 8 when the last observations were made in that vicinity, only one bird was known to have been killed — an adult from Area III that was a victim of highway traffic.

The nest burrow on Area I, Section 19, Summit Township, was in an alfalfa field (Fig. 1) with a gently undulating topography. The slope was westward. The estimated percentages of land use within a one-quarter mile radius of this burrow were: Alfalfa 50, corn 15, sweet clover 15, pasture 16, and gravel road 4. The nest burrow on Area II, Section 22, Waterford Township, was in a closely grazed pasture and had an easterly exposure. The topography here was gently undulating. The estimated percentages of land use within a quarter mile radius were: Pasture 60, soybeans 13, oats 15, corn 10, and gravel road 2. The nest burrow on Area III was in a moderately grazed pasture, and the percentages of land use within a quarter mile radius were estimated as: Pasture 32, oats 50, corn 10, farmstead 4, and gravel road 4. The exposure was southerly, and the topography of this tract was rolling.

The owl burrows on all three areas had been dug by the badger *(Taxidea t. taxus)*. In addition to pellet fragments the entrances to the nest burrows (Fig. 2) were carpeted with finely chipped, dry horse droppings and cow dung. This characteristic conformed with the observation of Bent (1938). Early in the summer the owls used only one burrow, presumably the nest burrow; as the summer wore on and the young became more active, other burrows were brought into use. On Area III signs of use by owls were evident at the openings of five burrows; all were within 50 feet of the nest burrow. The owls on Area I left their nest burrow in the alfalfa field on July 6 when a cutting was being made. Temporary residence was taken up one-eighth of a mile south in a burrow in a sweet clover field. When the alfalfa was harvested, the owls returned to the nest burrow.

Adult owls could be seen at almost any time of day perched on fence posts or telephone poles near the burrow, or busy hunting and feeding the young. It was impossible to approach a nest burrow without being seen from some point of vantage by an adult bird. A warning call invariably sent the young scuttling into the burrow. Adults were occasionally noted at the den, where they sometimes bowed low to avoid being seen, or if the intruder came too close, flew away or retired within.

An attempt was made to determine the food habits of these burrowing owls. The only food item, other than insect fragments, about any of the burrows was a toad *(Bufo americanus)* observed July 25 on Area III. The toad may well have been killed and fed upon by some animal other than the owls. During

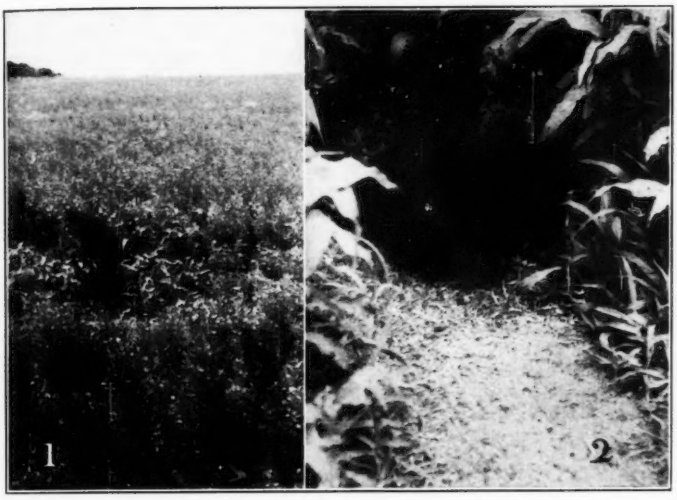


Fig. 1. The nest burrow site in the alfalfa on Area I.
Fig. 2. The entrance to the nest burrow on Area I.

Fig. 3. A sentinel at the burrow on Area III peers above the vegetation in search of an intruder.

the course of the observations 249 pellets were collected from about the burrows, fence posts, telephone poles, and roads. Analysis of these pellets supported in general the findings of Errington and Bennett (1935) for burrowing owls in northwestern Iowa in 1933. The kind and frequency of the foods contained in the pellets are presented in Table 2. Credit is due Dr. H. H. Knight, Department of Zoology and Entomology, Iowa State College, for giving assistance with the more difficult insects.

A field of shocked oats on Area III provided unusual opportunities to observe the owls feeding. Grasshoppers (largely *Melanoplus bivittatus*) were frequently seen on these shocks. An owl would sail close to the shock and snatch a grasshopper in its talons; it would then return to the shock or go to a nearby fence post to eat it. The size of the prey (see tables) indicated that the greater part of the food was first taken in the talons, as insects noticeably smaller than grasshoppers were found in but few pellets.

During the course of the day the birds made many trips to the gravel roads. Gravel was frequently found in pellets, but it was not known whether the gravel was accidentally or purposely ingested.

The six foods of greatest frequency in the pellets were: *Bolbocerasoma farctum, Phyllophaga* sp., *Ligyrus gibbosus, Melanoplus* sp., *Peromyscus* sp., and undetermined carabids. Thus it is noted that a substantial proportion of the food was of scarab beetles.

Remains of a very young cottontail *(Sylvilagus floridanus mearnsii)* occurred in one pellet. Adult cottontails were observed on all the areas, but their remains were not found in the pellets, and no attempt to capture an adult was observed. The thirteen-striped ground squirrel *(Citellus tridecemlineatus)* seemed to be representative of the upper size limit of prey.

In one pellet were found the remains of three distinct feet of undetermined Fringillidae. Possibly these were of nestlings or young just out of the nest, and hence easy prey.

A study of the food consumed on the three areas showed seasonal variation of the insects eaten. The progression of the life cycles of this kind of prey seemed to bring about most of these changes. *Ligyrus gibbosus, Phyllophaga* sp. and *Bolbocerasoma farctum* occurred in greater frequency during the periods prior to August 1. *Melanoplus* sp. were of almost no importance from June 15 to 30, but thereafter increased to the point of appearing in 96.2 percent of the pellets between August 1 and 15. For comparison with a vertebrate, the steadiness in frequency of the deer mouse, *Peromyscus* sp., may be noted.

A comparison of the foods in the pellets collected from each of the areas between June 15 and August 1 proved possible (Table 1). The food taken on these separated areas selected at random was remarkably similar in kind and proportion. Small mammals, especially *Peromyscus* sp., were not taken so frequently on Area I as on Areas II and III. Possibly harvest operations of the large quantity of alfalfa on Area I served to partially evict these prey

species from the area. The pellets from Areas I and III compared quite well in *Melanoplus* sp. consumption, but these grasshoppers were noticeably absent in those from Area II. The paucity of succulent food plants seemed to explain the near absence of grasshoppers on this area. Estimated percentages of plant food suitable to grasshoppers within a one-quarter mile radius of the nest den on each of the three areas were as follows: Area I 80, Area II 25, and Area III 75. *Hydrophilus triangularis* was taken most often on Area III where also was found a favorable environment for this species. *Canthon chalcites* was most frequent on Area II, and scarabids in general were most common on Areas I and II. For the most part the variation in diet among the three burrowing owl families appeared to have been largely caused by the effect of habitat restrictions on the prey populations.

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TABLE 1.—Comparison of Food by Areas. (June 15 to August 1, 1938)

| Food Items | Area I 64 pellets | | Area II 74 pellets | | Area III 77 pellets | |
|---|---|---|---|---|---|---|
| | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications |
| Vertebrata, Undetermined | 2 | .87 | 2 | .69 | 3 | 1.09 |
| Salientia, Undetermined | 8 | 3.46 | 14 | 4.81 | 7 | 2.54 |
| *Rana pipiens* | 1 | .43 | | | 1 | .36 |
| Mammalia, Undetermined | | | | | 1 | .36 |
| *Blarina b. brevicauda* | | | | | 1 | .36 |
| *Citellus t. tridecemlineatus* | | | 2 | .69 | 2 | .72 |
| *Cricetidae*, Undetermined | 4 | 1.73 | 7 | 2.41 | 6 | 2.17 |
| *Reithrodontomys megalotis dychei* | 1 | .43 | 1 | .34 | | |
| *Peromyscus* sp. | 5 | 2.16 | 16 | 5.50 | 22 | 7.97 |
| *Synaptomys cooperi gossii* | | | 1 | .34 | | |
| *Microtus* sp. | 2 | .87 | 1 | .34 | 3 | 1.09 |
| *Microtus p. pennsylvanicus* | | | 4 | 1.37 | | |
| *Mus m. musculus* | | | 1 | .34 | | |
| *Sylvilagus floridanus mearnsii* | | | 1 | .34 | | |
| Aves, Undetermined | 1 | .43 | | | | |
| Egg shell | 1 | .43 | | | | |
| *Sturnella neglecta* | | | 1 | .34 | 1 | .36 |
| Fringillidae | | | | | 1 | .36 |
| *Liobunum* sp. | | | 2 | .69 | 2 | .72 |
| Insecta, Undetermined | | | | | 1 | .36 |
| Diptera, Undetermined | 1 | .43 | | | 1 | .36 |
| Lepidoptera, Undetermined | | | 1 | .34 | 2 | .72 |
| Locustidae, Undetermined | 5 | 2.16 | 1 | .34 | 5 | 1.81 |
| *Melanoplus* sp. | 27 | 11.69 | 5 | 1.72 | 40 | 14.49 |
| *Gryllus assimilis* | 3 | 1.30 | 7 | 2.41 | 6 | 2.17 |
| Coleoptera, Undetermined | 3 | 1.30 | 1 | .34 | 2 | .72 |
| *Cicindella sexguttata* | 1 | .43 | | | | |
| Carabidae, Undetermined | 23 | 9.96 | 22 | 7.56 | 31 | 11.23 |
| *Calosoma scrutator* | 2 | .87 | | | | |
| *Calosoma calidum* | 11 | 4.76 | 10 | 3.44 | 8 | 2.90 |
| *Calosoma externum* | 4 | 1.73 | | | 2 | .72 |
| *Evarthus* sp. | | | | | 1 | .36 |
| *Harpalus caliginosus* | 3 | 1.30 | 4 | 1.37 | 3 | 1.09 |
| *Chlaenius* sp. | 4 | 1.73 | 10 | 3.44 | 5 | 1.81 |
| *Chlaenius nemoralis* | | | 1 | .34 | | |
| *Clivina bipustulata* | | | 1 | .34 | | |

TABLE 1. (Continued)—Comparison of Food by Areas. (June 15 to August 1, 1938)

| Food Items | Area I 64 pellets | | Area II 74 pellets | | Area III 77 pellets | |
|---|---|---|---|---|---|---|
| | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications |
| *Scarites substriatus* | 3 | 1.30 | 4 | 1.37 | 3 | 1.09 |
| *Scarites* sp. | | | 1 | .34 | 2 | .72 |
| *Pasimachus elongatus* | 10 | 4.33 | 11 | 3.78 | 6 | 2.17 |
| *Hydrophilus triangularis* | 1 | .43 | 2 | .69 | 6 | 2.17 |
| Silphidae, Undetermined | | | | | 2 | .72 |
| *Necrophorus* sp. | 5 | 2.16 | 13 | 4.47 | 9 | 3.26 |
| *Hister americanus* | 4 | 1.73 | 1 | .34 | | |
| Elateridae, Undetermined | 3 | 1.30 | 1 | .34 | 5 | 1.81 |
| *Melanotus* sp. | | | 3 | 1.03 | 4 | 1.45 |
| *Limanius auripilus* | | | | | 1 | .36 |
| *Aeolis dorsalis* | 1 | .43 | | | | |
| Lucanidae, Undetermined | 1 | .43 | | | | |
| Tenebrionidae, Undetermined | 2 | .87 | | | 3 | 1.09 |
| *Eleodes* sp. | | | | | 1 | .36 |
| *Eleodes suturalis* | | | 1 | .34 | 1 | .36 |
| *Boletophagus depressus* | | | | | 1 | .36 |
| Scarabidae, Undetermined | | | 2 | .69 | 2 | .72 |
| *Canthon chalcites* | | | 17 | 5.84 | 3 | 1.09 |
| *Copris anaglypticus* | 2 | .87 | 8 | 2.75 | 9 | 3.26 |
| *Ligyrus relictus* | 1 | .43 | 1 | .34 | | |
| *Ligyrus gibbosus* | 33 | 14.29 | 31 | 10.65 | 21 | 7.61 |
| *Onthophagus hecate* | 1 | .43 | 1 | .34 | 2 | .72 |
| *Bolboceras lazarus* | 4 | 1.73 | 4 | 1.37 | 2 | .72 |
| *Bolbocerasoma farctum* | 18 | 7.79 | 17 | 5.84 | 13 | 4.71 |
| *Trox punctatus* | | | | | 1 | .36 |
| *Phyllophaga* sp. | 25 | 10.82 | 47 | 16.15 | 17 | 6.16 |
| *Pelidnota punctata* | 1 | .43 | | | 2 | .72 |
| Chrysomelidae, Undetermined | | | | | 1 | .36 |
| *Zygogramma suturalis* | | | 1 | .34 | | |
| Curculionidae, Undetermined | 2 | .87 | 4 | 1.37 | 1 | .36 |
| *Baris deformis* | | | 1 | .34 | | |
| *Calendra* sp. | | | 1 | .34 | | |
| Formicidae | 2 | .87 | 3 | 1.30 | 1 | .36 |

TABLE 2.—Summer Food of the Western Burrowing Owl.

| Food Items | June 15-30 71 pellets | | July 1-15 94 pellets | | July 16-31 46 pellets | | August 1-15 38 pellets | | Totals 249 pellets | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications |
| Vertebrata, Undetermined | 3 | 1.16 | 3 | .75 | 1 | .74 | | | 7 | .79 |
| Salientia, Undetermined | 7 | 2.70 | 17 | 4.24 | 5 | 3.68 | | | 29 | 3.27 |
| *Rana pipiens* | 1 | .39 | | | 1 | .74 | | | 2 | .23 |
| Mammalia, Undetermined | 1 | .39 | | | | | | | 1 | .11 |
| *Blarina b. brevicauda* | 1 | .39 | | | | | | | 1 | .11 |
| *Citellus t. tridecemlineatus* | | | 4 | 1.00 | | | | | 4 | .45 |
| Cricetidae, Undetermined | 8 | 3.09 | 4 | 1.00 | 5 | 3.68 | 2 | 2.22 | 19 | 2.15 |
| *Reithrodontomys megalotis dychei* | 2 | .77 | | | | | 1 | 1.11 | 3 | .34 |
| *Peromyscus* sp. | 16 | 6.18 | 18 | 4.49 | 9 | 6.62 | 9 | 10.00 | 52 | 5.87 |
| *Synaptomys cooperi gossii* | 1 | .39 | | | | | | | 1 | .11 |
| *Microtus* sp. | 3 | 1.16 | | | 3 | 2.21 | 1 | 1.11 | 7 | .79 |
| *Microtus p. pennsylvanicus* | 3 | 1.16 | 1 | .25 | | | | | 4 | .45 |
| *Mus m. musculus* | | | | | 1 | .74 | | | 1 | .11 |
| *Sylvilagus floridanus mearnsii* | 1 | .39 | | | | | | | 1 | .11 |
| Aves, Undetermined | 1 | .39 | | | | | | | 1 | .11 |
| Egg shell | 1 | .39 | | | | | | | 1 | .11 |
| *Sturnella neglecta* | 2 | .77 | | | | | | | 2 | .23 |
| Fringillidae | | | | | 1 | .74 | | | 1 | .11 |
| *Liobunum* sp. | | | 3 | .75 | 1 | .74 | | | 4 | .45 |
| Insecta, Undetermined | 1 | .39 | | | | | 1 | 1.11 | 2 | .23 |
| Diptera, Undetermined | | | 1 | .25 | 1 | .74 | 1 | 1.11 | 3 | .34 |
| Lepidoptera, Undetermined | 1 | .39 | 1 | .25 | 1 | .74 | | | 3 | .34 |
| Locustidae, Undetermined | | | 6 | 1.50 | 5 | 3.68 | 1 | 1.11 | 12 | 1.35 |
| *Melanoplus* sp. | 1 | .39 | 46 | 11.47 | 25 | 18.38 | 37 | 41.11 | 109 | 12.31 |
| *Gryllus assimilis* | 4 | 1.54 | 12 | 2.99 | | | 2 | 2.22 | 18 | 2.03 |
| Coleoptera, Undetermined | 2 | .77 | 2 | .50 | 2 | 1.47 | 1 | 1.11 | 7 | .79 |
| *Cicindella sexguttata* | 1 | .39 | | | | | | | 1 | .11 |
| Carabidae, Undetermined | 22 | 8.49 | 36 | 8.98 | 18 | 13.24 | 12 | 13.33 | 88 | 9.94 |
| *Calosoma scrutator* | 1 | .39 | 1 | .25 | | | | | 2 | .23 |
| *Calosoma calidum* | 12 | 4.63 | 15 | 3.74 | 2 | 1.47 | | | 29 | 3.27 |
| *Calosoma externum* | | | 5 | 1.25 | 1 | .74 | | | 6 | .68 |
| *Pterostichus* sp. | | | | | | | 1 | 1.11 | 1 | .11 |
| *Evarthus* sp. | | | 1 | .25 | | | | | 1 | .11 |
| *Harpalus caliginosus* | 3 | 1.16 | 6 | 1.50 | 1 | .74 | 1 | 1.11 | 11 | 1.24 |
| *Chlaenius* sp. | 10 | 3.86 | 6 | 1.50 | 3 | 2.21 | | | 19 | 2.15 |
| *Chlaenius nemoralis* | | | 1 | .25 | | | | | 1 | .11 |
| *Clivina bipustulata* | | | 1 | .25 | | | | | 1 | .11 |

TABLE 2. (Continued)—Summer Food of the Western Burrowing Owl.

| Food Items | June 15-30 71 pellets | | July 1-15 94 pellets | | July 16-31 46 pellets | | August 1-15 38 pellets | | Total 249 pellets | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications | Number of Identifications | % of total Identifications |
| *Scarites* sp. | 1 | .39 | 2 | .50 | | | | | 3 | .34 |
| *Scarites substriatus* | 4 | 1.54 | 6 | 1.50 | | | | | 10 | 1.13 |
| *Pasimachus elongatus* | 13 | 5.02 | 13 | 3.28 | 1 | .74 | | | 27 | 3.05 |
| *Hydrophilus triangularis* | 4 | 1.54 | 5 | 1.25 | | | | | 9 | 1.02 |
| *Silphidae*, Undetermined | | | 2 | .50 | | | 1 | 1.11 | 3 | .34 |
| *Necrophorus* sp. | 5 | 1.93 | 17 | 4.24 | 5 | 3.68 | 6 | 6.67 | 33 | 3.73 |
| *Hister americanus* | 5 | 1.93 | | | | | | | 5 | .56 |
| *Elateridae*, Undetermined | 5 | 1.93 | 4 | 1.00 | | | | | 9 | 1.02 |
| *Melanotus* sp. | | | 5 | 1.25 | 2 | 1.47 | | | 7 | .79 |
| *Limanius auripilus* | | | 1 | .25 | | | | | 1 | .11 |
| *Aeolis dorsalis* | | | 1 | .25 | | | | | 1 | .11 |
| *Lucanidae*, Undetermined | 1 | .39 | | | | | | | 1 | .11 |
| Tenebrionidae, Undetermined | 1 | .39 | 3 | .75 | 1 | .74 | | | 5 | .56 |
| *Eleodes* sp. | | | | | 1 | .74 | | | 1 | .11 |
| *Eleodes suturalis* | 1 | .39 | | | | | | | 1 | .11 |
| *Boletophagus depressus* | | | 1 | .25 | | | | | 1 | .11 |
| Scarabidae, Undetermined | 2 | .77 | 2 | .50 | | | 2 | 2.22 | 6 | .68 |
| *Canthon chalcites* | 10 | 3.86 | 10 | 2.50 | | | | | 20 | 2.26 |
| *Copris anaglypticus* | 10 | 3.86 | 6 | 1.50 | 3 | 2.21 | | | 19 | 2.15 |
| *Ligyrus relictus* | 1 | .39 | 1 | .25 | | | | | 2 | .23 |
| *Ligyrus gibbosus* | 31 | 11.97 | 35 | 8.73 | 19 | 13.97 | 3 | 3.33 | 88 | 9.94 |
| *Onthophagus hecate* | 2 | .77 | | | 2 | 1.47 | | | 4 | .45 |
| *Bolboceras lazarus* | 1 | .39 | 7 | 1.75 | 2 | 1.47 | | | 10 | 1.13 |
| *Bolbocerasoma farctum* | 3 | 1.16 | 39 | 9.73 | 6 | 4.41 | 6 | 6.67 | 54 | 6.10 |
| *Trox punctatus* | | | | | 1 | .74 | | | 1 | .11 |
| *Phyllophaga* sp. | 42 | 16.22 | 42 | 10.47 | 5 | 3.68 | 1 | 1.11 | 90 | 10.16 |
| *Pelidnota punctata* | | | 1 | .25 | 2 | 1.47 | | | 3 | .34 |
| Chrysomelidae, Undetermined | | | 1 | .25 | | | | | 1 | .11 |
| *Zygogramma suturalis* | | | 1 | .25 | | | 1 | 1.11 | 2 | .23 |
| Curculionidae, Undetermined | 5 | 1.93 | 2 | .50 | | | | | 7 | .79 |
| *Baris deformis* | | | 1 | .25 | | | | | 1 | .11 |
| *Calendra* sp. | 1 | .39 | | | | | | | 1 | .11 |
| Formicidae | 2 | .77 | 3 | .75 | | | | | 5 | .56 |

# Some Foods of Young Great Blue Herons[1]

Charles M. Kirkpatrick

## Introduction

In the course of investigations by the Wisconsin Geological and Natural History Survey concerning the productivity of some of the lakes in the Trout Lake region of northeastern Wisconsin, it was observed that these waters furnished a supply of food for considerable numbers of fish-eating birds. These birds include the great blue heron *(Ardea herodias herodias)*, the American merganser *(Mergus merganser americanus)*, the common loon *(Gavia immer immer)*, and the belted kingfisher *(Megaceryle alcyon alcyon)*. All of these are common breeders in the region but the great blue heron is the most conspicuous from the standpoint of numbers as well as size. From the first of June until the latter part of August one or several of these herons can almost always be seen on any lake known to contain fish.

Within a radius of a few miles of Trout Lake two great blue heron rookeries have been located and it seems likely that there are more in the vicinity. One of these rookeries was made up of 138 nests in the 1940 season. The other consisted of 75 nests. Only active nests were counted. Active nests were designated as such only when young birds could be seen in the nests, or when whitewash evidence was plain enough to indicate that the nest was or had been recently occupied. When the nest census was made from one to four young could be seen in most of the nests. Later experience revealed that when not being fed some or all of the young birds lie quietly on the nest, completely hidden from view beneath. Thus some of the nests originally thought to contain only one bird, later were found to have two, three, or even four. On this basis it is probably safe to assume that the average number of young to a nest was at least two, and perhaps three.

Since it was obvious that the lakes supported this heron population to a great extent, it became desirable to the group engaged in fish growth and population studies to determine what part fishes played in the diet of the herons. This was to be accomplished by first identifying the kinds of food taken by the herons. Then an estimate was to be made of the total pounds of fish consumed by either one or both rookeries during a given period of time. This estimate, calculated for the nesting season, would indicate, perhaps, whether the predation of the herons upon the fishes constituted any appreciable drain upon this important natural resource of the lake region. Obviously any such estimate would have to be based on definite observations as to the number of times a young heron was fed in a certain period and the quantity of food it received at each feeding.

1 From the Limnological Laboratory of the Wisconsin Geological and Natural History Survey. This investigation was financed by the Wisconsin Conservation Department.

### Results of Other Investigators

From the reports of many writers it has long been common knowledge that herons feed upon many different kinds of fishes, as well as amphibians, reptiles, crustaceans, insects, and even birds and mammals. Such reports usually omit figures regarding the size of any fish or other animal taken, the food capacity of either an adult or a young heron, and the total consumption of a heron over any given period of time. Cottam (1936) and Chapin (1932) have reported the results of their analyses of a number of great blue heron stomachs. However, in the former instance, the stomachs were collected over a very wide range, and the food they contained was of such general nature as to be practically valueless for any local or seasonal comparison. Though Chapin found fishes to be 60 per cent of the contents of 70 stomachs, he also found that crustaceans and field mice were 14 and 6 per cent, respectively, of the total. Since field mice and crustaceans (presumably crayfish) are relatively scarce in the Trout Lake region, this food habit study was also of doubtful value in answering the question of what the local herons were eating.

Regarding the size of fishes taken by great blue herons, Forbush (1925) states that black bass weighing one and one-half pounds have been regurgitated by the young. Mosely (1936) reports that a colleague saw a heron swallow a bullhead which was estimated to weigh at least one and one-half pounds. Jackson (1923) saw herons catch yellow perch seven inches long. Bain (1885) alarmed a (great) blue heron which disgorged "ten good sized fish." These observations certainly indicate that the bird is capable of catching, swallowing and feeding to its young something more than small fishes.

Sportsmen and fishermen native to the Trout Lake region assert that the "cranes" take only game fishes. Fish hatchery men usually agree with this opinion, but most ornithologists are not yet convinced that the great blue heron is ever anything more harmful than an occasional local menace to a valuable fish population. With these fundamental questions unanswered, a preliminary survey was begun in 1940 in an attempt to learn the kinds of fishes, the sizes and quantities of each taken by the herons and fed to their young. Some interesting data were gathered which answered, to a certain extent, the questions of identity of food items and their sizes, but these data could not be quantified with respect to the number of birds studied in the time available for this investigation.

### Method of Collecting Food Items

At first it was hoped that some of the young herons could be captured alive and made to regurgitate shortly after being fed. This plan was not feasible for several reasons. A large majority of the nests were located on the dead branches of yellow birch trees, and so were inaccessible to the climber. A few of the nests could be reached, but when approached, the occupants promptly expelled the contents of their alimentary canals by regurgitating and defecating, and then left the nest. Some flapped awkwardly away on untried wings. Those not feathered enough to fly climbed to the tips of the outermost branches and could not be secured without being knocked from the tree. Sometimes they jumped from the nest, falling heavily to the ground. Since those

nests which could be approached were vacated in this manner, it was apparent that any quantitative estimate of the food consumed by the rookery would be difficult. It was observed, however, that the process of regurgitation was not confined to those nests being examined. Any disturbance on the ground, even the conspicuous presence of the observer, frequently caused the young in that immediate part of the rookery to disgorge parts of their last meals. This material fell to the ground beneath the nests. Moseley (1936) reports a similar observation for an Ohio rookery. In the absence of a better method for obtaining the food from the young, this peculiar behavior was exploited.

Deliberately alarming the nestlings by shaking brush, breaking sticks, rapping the trunks of trees and throwing stones into them was the procedure. This was effective for several weeks and 297 food specimens were collected from the two rookeries. Some of the specimens were not secured as a result of this persuaded regurgitation, for it was observed that morsels of food, particularly whole fishes, were sometimes accidentally dropped when the young were fed. Also ten young herons were collected during the course of the study and the specimens taken from them follow: One stomach contained a northern pike *(Esox lucius)* thirteen inches long; one contained the remains of two crayfish (*Cambarus* spp.); one contained remains of fishes, crayfish, and dragonflies *(Odonata);* one contained remains of two dragonflies; one contained four largemouthed bass *(Huro salmoides),* three of which were whole fish 7½, 3½, 3½, and one fragment 7½ inches long. The total weight was eight ounces; one contained two yellow perch *(Perca flavescens),* 5 inches long, one giant waterbug (*Lethocerus* sp.), and one back-swimmer (*Notonecta* sp.); three stomachs were empty, two of them from birds caught on the ground.

### Kinds of Food

Both of the previously mentioned rookeries were studied. The one of 138 nests was observed more closely since it was more conveniently located, and also the larger number of nests suggested a possible utilization of a greater variety of food materials. The total food material collected from June 28 until August 7 included the following:

| | |
|---|---|
| Crustacea | |
| Crayfish (Cambarus sp.) | 6 |
| Insecta | |
| Dragonfly (Odonata) | 3 |
| Back-Swimmer (Notonecta sp.) | 1 |
| Giant Water-Bug (Lethocerus sp.) | 1 |
| Amphibia | |
| Leopard Frog *(Rana pipiens)* about 2 inches long, some bearing larval tails | 12 |
| Pisces | |
| Species given in Table 1 | 273 |
| Mammalia | |
| Muskrat *(Ondatra zibethica zibethica),* young, with body length of 6 inches | 1 |
| | 297 |

### Description of Food Material

About 92 per cent of the total food material collected consisted of whole fishes and identifiable fragments. Fifteen different species were encountered, thirteen of which were recognized. Table 1 shows that these fishes covered a length range from two to sixteen inches. The weight range was from less than one ounce to fourteen ounces. The largest specimen measured was an Esox sp. fragment sixteen inches long without the head. Surprisingly large fishes armed with formidable spines can be captured, swallowed, and regurgitated by the great blue heron. Such fishes are often fed to the young. One yellow pike-perch *(Stizostedion vitreum vitreum)* was twelve inches long and weighed twelve ounces (Fig. 1). Figure 2 shows the remains of what are thought to be north-

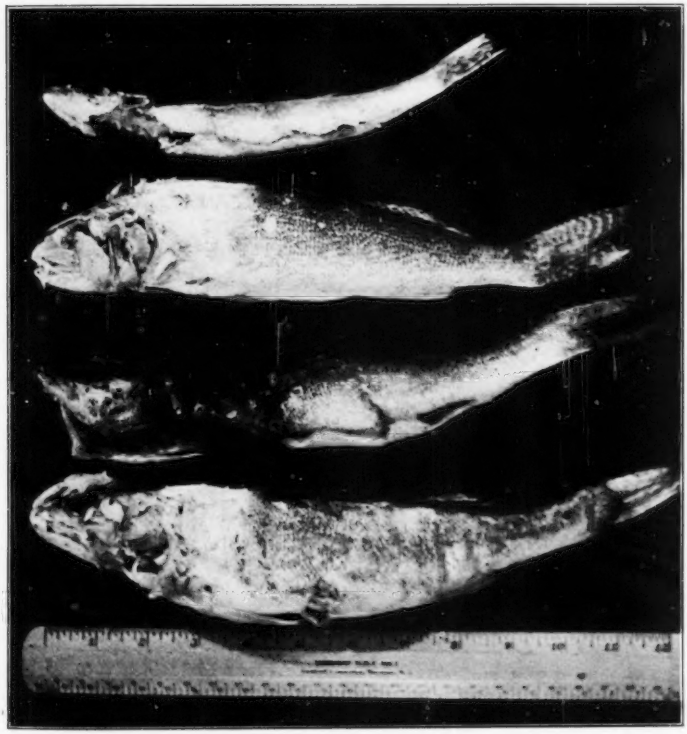

Fig. 1. Yellow pike-perch *(Stizostedion vitreum vitreum)* which were a part of the food of young great blue herons.[2]

[2] The photographs were made by Dr. P. L. Carpenter, Department of Bacteriology, Iowa State College, Ames, Iowa.

ern pike. The second fish from the ruler was taken from the stomach of a half grown heron. The fish was thirteen inches long and weighed ten ounces. Figure 3 illustrates that legal game fishes may be taken by the herons. The largest of the large-mouthed bass, disgorged by a young heron, was eleven inches long and weighed fourteen ounces. One single meal of a heron was found to be four large-mouthed bass with a total weight of eight ounces.

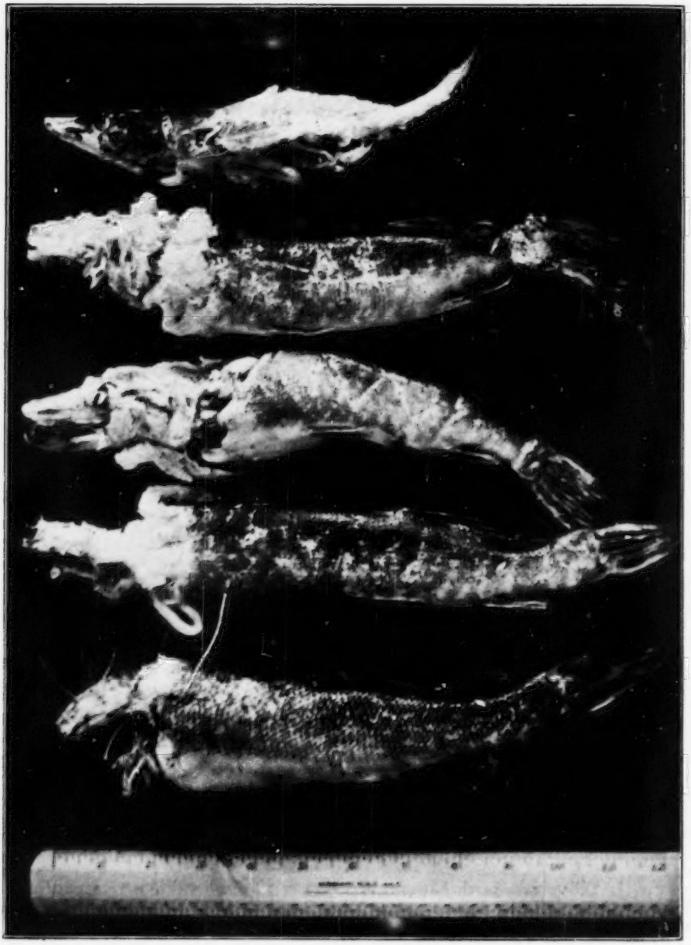

Fig. 2. The larger specimens of the Esox fish, probably northern pike *(Esox lucius)*.

Since the food items were collected over a period of about forty days, they were assumed to constitute a fair sample of the diet of the herons. Reference to Table 1 shows that the birds do not restrict their predation to large fishes or even to game fishes. More than 50 per cent of all the food items were yellow perch. Young perch are often regarded as forage for game fishes; it will be seen that the smaller specimens, between four and six inches in length, were the most abundantly taken. This is paralleled in the length group totals of all fishes. The number of those specimens not over eight inches long greatly exceed the total of those over eight inches. It must not be overlooked, however, that

Fig. 3. Large-mouthed bass (*Huro salmoides*).

more than half of all the fishes in the first six columns were fragments. During the study special care was taken to compare the size of fragments with whole fish of the same species. It was found that in most cases the fragments were not more than half of the whole fish. Thus if these fragments were translated into the whole fishes of which they are a part, there would be no such majority as the smaller fishes now have in the length group totals. Strangely, 12 of the 21 yellow pike-perch were over eight inches in length, as were 12 of the 14 Esox spp.

The frequency with which yellow perch, yellow pike-perch, and perhaps rock bass *(Ambloplites rupestris)* occur as food items may indicate a preference, but it suggests more strongly an abundance of these species in the waters fished. It is usually accepted that a predator will put most pressure on that prey species which is most abundant. Also, it does not seem reasonable that a heron would prefer the spiny-rayed fishes of the perch and sunfish families to those of the soft-rayed sucker family. At present no explanation can be given why the larger fishes in the collection were mostly of game fish variety. Possibly some environmental habit, peculiar to these fishes, made them easily available to the fishing herons.

Not enough observations were made to justify a serious attempt to calculate the fish consumption of a rookery for any given period of time. However, Moseley (1936) reports an Ohio rookery of 1,018 nests. He suggests that "after the young are half grown, a ton of fish a day probably would not satisfy them." Some of the data gathered in this study would seem to indicate that his estimate of two pounds of fish per day is not an impossible capacity or even an unreasonable requirement for a nest of half grown herons.

While the data on which this preliminary report is based are limited, they show conclusively that a more detailed study is warranted and very desirable to complete the picture of the heron-fish relationship in the Trout Lake region.

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Table 1.—Whole fishes and identifiable fragments from two rookeries given according to species and size of food item.

TABLE 1.—Whole fishes and identifiable fragments from two rookeries given according to species and size of food item. Number of fragments given in parentheses.

| Kind of fish | Length in inches | | | | | | | | | | | | | Species total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2¼-3 | 3¼-4 | 4¼-5 | 5¼-6 | 6¼-7 | 7¼-8 | 8¼-9 | 9¼-10 | 10¼-11 | 11¼-12 | 12¼-13 | 13¼-14 | 16 | |
| Yellow perch *(Perca flavescens)* | 18 (2) | 16 (8) | 13 (28) | 12 (24) | 8 (10) | 1 (9) | 3 (1) | (1) | | | | | | 71 (83) |
| Yellow pike-perch *(Stizostedion v. vitreum)* | | (2) | | 3 (1) | (3) | | 1 (5) | 1 (2) | 1 (1) | 1 | | | | 7 (14) |
| Northern rock bass *(Ambloplites rupestris)* | (2) | 1 (3) | 1 (2) | 1 (4) | (2) | 2 (1) | (1) | | | | | | | (5) (15) |
| Common white sucker *(Catastomus c. commersonnii)* | | | 1 (2) | (1) | (2) | (3) | (4) | 1 (1) | (2) | | | | | 2 (15) |
| Esox spp., probably Northern pike *(Es x lucius)* | | 2 | | | | | 1 (2) | (1) | (2) | 1 (2) | (1) | 1 | (1) | 5 (9) |
| Large-mouthed bass *(Huro salmoides)* | | 2 (1) | | (2) | (1) | 1 (1) | 1 | (1) | 1 | | | | | 5 (6) |
| Northern black bullhead *(Ameiurus m. melas)* | 1 | | 2 | | (2) | 2 (2) | | | | | | | | 3 (6) |
| Bluegill *(Lepomis macrochirus)* | 2 | 1 | 1 | 3 | 2 | | | | | | | | | 9 |
| Pumpkinseed *(Lepomis gibbosus)* | | | 2 (1) | (2) | 1 (1) | | | | | | | | | 3 (4) |
| Black crappie *(Pomoxis nigro-maculatus)* | | (1) | (2) | | | (1) | | | | | | | | (4) |
| Bowfin *(Amia calva)* | | | | (1) | | | | 1 | | | | | | 1 (1) |
| Northern small-mouthed bass *(Micropterus d. dolomieu)* | (1) | | | | | | | 1 | | | | | | 1 (1) |
| Western mudminnow *(Umbra limi)* | 1 | | | | | | | | | | | | | 1 |
| Stickleback sp. | 1 | | | | | | | | | | | | | 1 |
| Cyprinid sp. | | 1 | | | | | | | | | | | | 1 |
| Length group totals of whole fishes and fragments | 23 (5) | 23 (15) | 18 (37) | 19 (35) | 11 (21) | 6 (17) | 6 (13) | 4 (6) | 2 (5) | 2 (2) | (1) | 1 | (1) | 115 (158) |
| Grand total of length groups | 28 | 38 | 45 | 54 | 32 | 23 | 19 | 10 | 7 | 4 | 1 | 1 | 1 | 273 |

# Records and Descriptions of North American Crane-Flies (Diptera)

## Part I. Tipuloidea of the Great Smoky Mountains National Park, Tennessee

Charles P. Alexander

### Introduction

I began the study of the North American Tipulidae in 1906 and since that date many thousand records of distribution of these flies have been gathered. Most of these data are still unpubiished and it is believed that a series of papers making available the more interesting of these records will add materially to our still insufficient knowledge of seasonal and geographical distribution in this family. With this idea in mind, the present paper has been prepared and it is hoped will be followed by others of similar nature.

### General Account

My interest in Tipulidae of the Great Smoky Mountains was aroused when collections made by Dr. Inez W. Williams and Dr. Arthur C. Cole in 1938 and 1939 indicated the extreme richness of the fauna (Cole 1938:276).* In June 1939, Mrs. Alexander and I, accompanied by Mr. and Mrs. Walter H. Harrison, camped for more than two weeks at the Chimneys Camp in the Tennessee Smokies and the extensive collections made at that time furnish the bulk of the records listed here. Besides the assistance given by Dr. Cole and Dr. Williams, further appreciated cooperation is acknowledged to Miss Mary E. Hickman (now Mrs. Cole) and to Mrs. John Huff. The collections made by Mrs. Huff, wife of the proprietor of Leconte Lodge near the summit of Mount Leconte, were made from June into September 1939 and furnished several records of species not taken by others. All members of our camping party assisted in the collecting of specimens on all of our many trips and this aid is gratefully acknowledged. Special mention is made of the friendliness of the Park Naturalist, Mr. Arthur Stupka, whose interest in the present report has proved a source of much satisfaction and encouragement. It is expected that further collecting in the Tennessee Smokies will be done in 1940 and in subsequent years. The present basic list includes 2 species of Ptychopteridae, together with 160 species of Tipulidae, of which no fewer than 16 species proved to be undescribed. The types of these novelties are preserved in my extensive collection of these flies.

* References in the text refer to the bibliography at the conclusion of this general account.

The only previous basic paper that considers the Tipulidae of Tennessee is the remarkably fine report of Dr. J. Speed Rogers, on the Summer Crane-fly fauna of the Cumberland Plateau, in Fentress, Morgan and Scott counties (Occas. Pap. Mus. Zool., Univ. Michigan, 215:1-50, 5 pls.; 1930). It is my opinion that this is one of the most valuable papers on the Tipulidae that has ever been published. The Cumberland Plateau report includes no fewer than 68 species of Tipulidae not represented in the present list for the Smokies. In addition, I have available some five further records for Tennessee, so the present State List is approximately 235 species, to which a number of additions will be made. This figure compares well with that of all states in the union excepting those where very detailed and long-term collecting has been done, as New York and Michigan, both of which have more than 300 known species of Tipulidae.

*Collecting Stations.*—The 1939 collections in Tennessee were made in Blount and Sevier counties. The conditions obtaining in the area have been well described by King (1939). The special stations where we collected may be defined briefly:

Chimneys Camp. We camped here between June 4 and 19, using this site as our base. Collections were made along the West Prong of the Little Pigeon River at the Camp (2,700 ft.) and down the main road from the entrance (2,600 ft.).

Over-the-Mountain or Newfound Gap Highway. This trans-montane road permits easy traversal of the Park. Special collecting was done along the Walker Camp Prong, between Grassy Patch (4,000 ft.) and Newfound Gap (5,000 ft.), along the southern spurs of Anakeesta Ridge in the vicinity of the upper tunnel. Such specimens are labelled *"Anakeesta Ridge."*

The "Skyway" or Forney Ridge Road. This spur road from Newfound Gap to Forney Ridge provides ready access to Andrews Bald (5,860 ft.) in North Carolina; Clingmans Dome (6,640 ft.), highest point in the Park; and along the Appalachian trail (5,000 6,000 ft.) towards Silers Bald. This trail follows the state line between North Carolina and Tennessee and collecting in either state may be done at will. Some further collections were made at Indian Gap (5,000 ft.), one mile from Newfound Gap along the Skyway, by Dr. Cole, Miss Hickman and myself.

Mount Leconte. A trip on June 12 and 13, via the Alum Cave Trail from Grassy Patch on the Newfound Gap Highway, via Alum Cave (5,000 ft.) to Leconte Summit (6,593 ft.). Detailed collecting was done at frequent intervals along the trail and in the boggy area near the spring of the Leconte Lodge (6,400 ft.). The return on the second day was by the Leconte Creek trail, Rainbow Falls and Cherokee Orchard.

Greenbrier Cove. Especially rich collecting along the Fire Road to the Outing Club cabin and along Porters Creek and Cannon Creek, via the Brushy Mountain trail to the summit of Brushy Mountain and return, by way of Half-way Spring and Trillium Gap. One of the most profitable trips taken was on June 15, in company with Dr. Cole, Miss Hickman, and all members of our party. A small accessory stream near the junction of Porters and the

Middle Prong of the Little Pigeon River (1,700 ft.) produced some interesting species, as did the main stream itself.

Cades Cove. Two trips were taken by our party, both via the road over Rich Mountain (2,050 ft.), June 10 and 17. We collected at Rich Mountain and in the vicinity of Myers Lodge, on Forge Creek (1,930 ft.), near the head of the Cove. On June 17, with Mr. and Mrs. Stupka, we took the trip to Gregory Bald via the Gregory Ridge Trail and Rich Gap (2,000-4,595 ft.). Unfortunately, heavy rains on this trip and some others greatly hampered collecting and materially reduced the number of species taken.

Little River Gorge. Some collecting was done along the cliffs of the gorge (1,400 ft.) while enroute to Cades Cove and elsewhere. The country is very definitely Upper Austral and will undoubtedly yield further interesting Tipulidae when thoroughly investigated.

*Plant Associations and Biotic Areas.*—The interrelations existing between Tipulidae and various plant associations are becoming better understood. The different associations and societies of plants harbor very definite species and groups of crane-flies (consult Rogers, J. S., reference previously cited; Alexander, C. P., Cornell Univ. Agr. Expt. Sta. Mem. 25:826-837; 1919). For the area under consideration, unusually complete and important data concerning the forest types of the Smokies are available. The staff and graduate students of the University of Tennessee, under Dr. Stanley A. Cain, Dean L. R. Hesler, Dr. Harry M. Jennison, Dr. Aaron J. Sharp, and others, have performed an invaluable service in rendering this information available to workers on other groups of organisms. The more important of these papers are cited in the brief bibliography furnished at the end of the present introductory account. Particularly helpful toward an appreciation of the interrelationships of the flora and the insect fauna has been the unpublished manuscript, prepared by Cain and co-workers, on the Greenbrier-Brushy Mountain trail (1937).

Cain and Sharp (1938:278) classify the primaeval forest types of the Great Smokies as follows:

1. The subalpine spruce—fir forest.
2. Cove hardwoods forests.
3. The chestnut—oak—hickory—pine complex.

A further subdivision of the first two, of particular interest in the present survey, is given (l.c., p. 250):

I. Prealpine belt. The Canadian spruce—fir forest.
   1. The southern balsam fir association. *Abies Fraseri* (Pursh) Lindl.
   2. The red spruce association. *Picea rubra* (DuRoi) Dietr. *(Picea rubens* Sargent).
   3. The beech gap associations. *Fagus grandifolia* Ehrh.

II. Montane belt. The Cove hardwoods forests.
   1. The buckeye—basswood association. *Aesculus octandra* Marsh.—*Tilia neglecta* Spach.
   2. The silverbell—sugar maple association. *Halesia monticola* (Rehder) Sargent —*Acer saccharum* Marsh.

3. The yellow poplar—hemlock association. *Liriodendron Tulipifera* L.—*Tsuga canadensis* (L.) Carr.

In this preliminary survey of the Tipulidae of the Tennessee Smokies, particular attention has been devoted to the six associations above listed, more especially the prealpine belt in the spruce-fir forest.

The definite stations established at various altitudes along the Brushy Mountain trail (Cain *et al.*, 1937) permit a detailed study and comparison with the insect fauna. The stations of greatest interest as they concern the Tipulidae are:

1. The hemlock ridge forest-type (3,000 ft.).
2. Buckeye—basswood forest-type (4,000 ft.).
3. Lead-type laurel slick (4,650 ft.).
4. Subalpine beech gap forest-type (4,717 ft.).
5. Brushy Mountain heath bald (4,900 ft.).
7. Pine-Heath (3,800 ft.).
8. Cove hardwoods, mixed type (2,950 ft.).
10. The red spruce forest-type (4,950 ft.).
11. The southern balsam fir forest-type (6,500 ft.).

The life zones or biotic areas of the Tennessee Smokies are three in number. The lowest, the *Upper Austral* or *Carolinian* includes the coves and the bases of the mountains, involving the Gorge of the Little River. The high summits down to the lower level of spruce and fir (to about 4,500 ft.) are definitely *Canadian* of various degrees. The intermediate zone is *Transition* or *Alleghanian*, invaded in the gullies and on the ridges by encroachments from the other two zones.

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## Systematic Account

### PTYCHOPTERIDAE

*Bittacomorphella jonesi* (Johnson, 1905).*—Leconte, Huffs Spring, 6,400 ft., June 12-13; Anakeesta Ridge, 4,700 ft., June 5; Greenbrier Cove, May 15, 1938 *(Williams);* Porters Creek, 3,500 ft., September 16 *(Cole & Hickman);* Cades Cove, Myers Lodge, 2,200 ft., June 17 *(M. M. Alexander).*

*Bittacomorpha clavipes* (Fabricius, 1781).—Greenbrier, near Forks, 1,700 ft., June 7 *(M. M. Alexander).*

### TIPULIDAE

#### TIPULINAE

*Longurio testaceus* Loew, 1869.—Chimneys Camp, 2,700 ft., at light, June 17 *(Cole & Hickman).*

*Longurio minimus* Alexander, 1914.—Leconte, Huffs Spring, 6,400 ft., September 9 *(Mrs. J. Huff).*

*Ctenophora nubecula* Osten Sacken, 1864.—Greenbrier, along Brushy Mt. trail, 2,500 ft., flying over prostrate log, June 15.

*Tanyptera frontalis* (Osten Sacken, 1864).—Indian Gap, 5,200 ft., June 10 *(Cole & Hickman).*

*Nephrotoma ferruginea* (Fabricius, 1805).—Indian Gap, 5,300 ft., June 9.

*Nephrotoma calinota* (Dietz, 1918).—Greenbrier, 1,700 ft., one ♀ ovipositing at margin of small stream.

*Nephrotoma incurva* (Loew, 1863).—Chimneys Camp, 2,700 ft., June 17 *(Cole & Hickman);* Park Headquarters, June 9 *(J. Manley);* Greenbrier, 1,800 ft., June 7; Cades Cove, Myers Lodge, 2,200 ft., June 17 *(M. M. Alexander).*

*Nephrotoma macrocera* (Say, 1823).—Silers Trail, 6,400 ft., June 6; Chimneys Camp, 2,700 ft., June 8; Greenbrier, 2,000 ft., May 15-22, 1938 *(Williams),* 2,500 ft., May 20 *(Williams),* 1,900 ft., June 7; Porters Creek, 3,500 ft., September 16 *(Cole & Hickman);* Cades Cove, 2,200 ft., June 17 *(M. M. Alexander).*

*Nephrotoma tenuis* (Loew, 1863).—Greenbrier, May 15, 1938 *(Williams).*

**Nephrotoma tenuis fuscostigmosa** subsp. nov.

♂. Length about 14 mm.; wing, 13.5 mm.; antenna, about 3.4 mm.

Antennae as in the typical form; flagellum black, the proximal ends of the first three or four segments pale, the outer ends and remaining segments uniformly blackened. Occipital brand with the anterior end blackened and

* In all cases in this report, dates without year were collected in 1939; where no collector is given, the specimens were secured by the author. M. M. Alexander= Mrs. Charles P. Alexander.

slightly produced forward onto the vertex; posterior portion of brand pale and scarcely differentiated; a dusky cloud on either side of anterior vertex.

Praescutal stripes dark brown, polished, well-defined, the median stripe with a broad reddish center throughout its length; scutal lobes extensively dark brown, including the lateral ends of the suture which are even more intensely blackened; scutellum darkened; mediotergite reddish yellow. Pleura and pleurotergite yellow, vaguely patterned with more reddish on the ventral sternopleurite. Wings with the costal border clearer yellow than remainder of wing; stigma brown, oval, well-delimited;veins dark brown, clearly defined, more yellowish in the costal and prearcular fields. Venation: Cell $M_1$ short-petiolate.

Abdomen with tergites infuscated medially, obscure yellow sublaterally, the sides with a narrow blackened area to form a broken lateral stripe; subterminal segments uniformly darkened. Male hypopygium with the inner dististyle (Fig. 1, *id*) having the dorsal crest very high and conspicuous, elongate, extending distad beyond the base of the beak; lobe at base of style a simple spine. Lobes of the eighth sternite with abundant elongate setae, those near the mesal

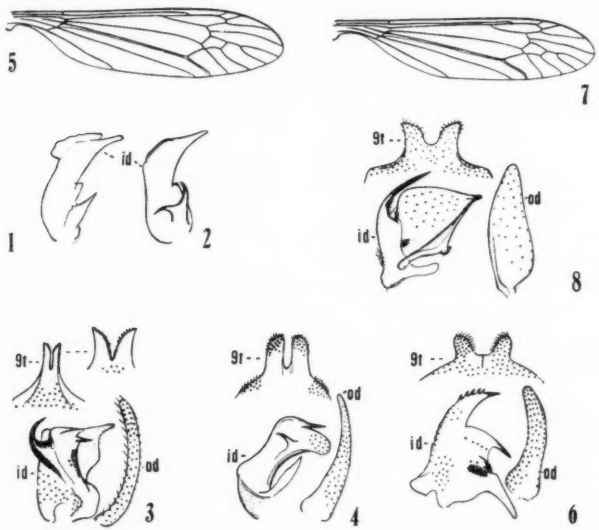


Fig. 1. *Nephrotoma tenuis fuscostigmosa* subsp.n.; male hypopygium, inner dististyle.
2. *Nephrotoma tenuis tenuis* (Loew); male hypopygium, inner dististyle.
3. *Tipula (Yamatotipula) brevifurcata* Alexander; male hypopygium.
4. *Tipula (Yamatotipula) iroquois* Alexander; male hypopygium.
5. *Tipula (Yamatotipula) catawbiana* sp.n.; venation.
6. *Tipula (Yamatotipula) catawbiana* sp.n.; male hypopygium.
7. *Tipula (Yamatotipula) nephophila* sp.n.; venation.
8. *Tipula (Yamatotipula) nephophila* sp.n.; male hypopygium.
(*Symbols: id*, inner dististyle; *od*, outer dististyle; *t*, 9th tergite.)

portions much more delicate but still elongate. Typical *tenuis* has the crest of the inner dististyle (Fig. 2, *id*) very low to scarcely evident; lobe at base of style bispinous. Setae of eighth sternite less numerous.

*Holotype*, ♂, Chimneys Camp, 2,700 ft., July 6, 1939 *(A. C. Cole)*.

I prefer to consider this as being a subspecies of *tenuis* until further specimens are discovered and the status confirmed. In the conspicuous praescutal stripes and distinct brown stigma, the fly more resembles a group of Austral species, *Nephrotoma cornifera* (Dietz), *N. okefenoke* (Alexander) and *N. urocera* (Dietz), all species with a large and conspicuous male hypopygium.

*Nephrotoma virescens* (Loew, 1864).—Silers trail, 6,200 ft., June 6; Leconte, Rainbow trail, 3,500-4,000 ft., June 13, several females ovipositing in wet soil along trail; Greenbrier, June 15 *(A. Stupka)*; Brushy Mt. trail, 2,500-3,000 ft., June 15, 3,500 4,500 ft., July 11 *(A. C. Cole)*.

*Tipula (Trichotipula) algonquin* Alexander, 1915.—Chimneys Camp, 2,700 ft., July 26 *(A. C. Cole)*.

*Tipula (Trichotipula) oropezoides* Johnson, 1909.—Anakeesta Ridge, 4,500 -4,700 ft., June 5 ;Leconte, Alum Cave trail, 5,600-6,000 ft., June 12 *(W. H. Harrison)*; Huffs Spring, 6,400 ft., June 12-13; Greenbrier, Brushy Mountain trail, 2,500 ft., May 20 *(Williams)*; May 7 *(A. C. Cole)*; Cades Cove, May 8, 1938 *(Williams)*.

*Tipula (Nobilitipula) collaris* Say, 1823.— Silers trail, 5,800 ft., June 6; Anakeesta Ridge, 3,300 ft., June 5, a mating pair *(M. M. Alexander)*; Leconte, 5,600 ft., June 13; Greenbrier, 2,500 ft., Brushy Mt. trail, May 7 *(A. C. Cole)*.

These specimens differ from typical *collaris* of the northeastern states in having the basal lobe of the inner dististyle of the male hypopygium stouter and subequal in diameter for most of its length, at tip abruptly narrowed into a spine. In typical *collaris* this lobe narrows very gradually to the apical spine.

*Tipula (Yamatotipula) brevifurcata* Alexander, 1926.— Silers trail, 6,000 ft., June 6; Greenbrier, 2,000 ft., May 15, 1938 *(Williams)*. Cades Cove, 1,900 ft., June 10 *(M. M. Alexander)*.

Male hypopygium (Fig. 3) with the median lobe of tergite, *9t*, heavily blackened, very narrow, at apex split into two parallel to very feebly divergent lobes, the mesal edges of which are provided with blackened spines; base of incision with delicate setulae. Outer dististyle, *od*, unusually long and slender, parallel-sided, the apex obtuse, the length exceeding seven times the greatest width. Inner dististyle, *id*, subquadrate, the beak very slender, subequal in general size and appearance to a powerful curved spine at opposite outer angle of style; a small to very small spine on face of disk.

*Tipula (Yamatotipula) iroquois* Alexander, 1915 (*cincta* Loew, 1863).— Anakeesta Ridge, 4,700 ft., June 5; Leconte, Alum Cave trail, 4,100-6,000 ft., June 12, common; Greenbrier, 2,500 ft., May 7 *(Williams)*; Brushy Mt. trail, 2,500 ft., June 15.

Male hypopygium (Fig. 4) with the lobes of the tergite, *9t*, elongate, with

blackened setae on distal half, the lobes separated from one another by a deep and very narrow notch that is narrower than the width of either lobe. Outer dististyle, *od*, long-attenuate to the very narrow apex. Inner dististyle, *id*, with the beak flattened, obtuse, with a long, subappressed spine along its outer edge and a more erect spine of approximately the same size on the face of the blade and directed more basad; a third, longer spine on inner portion of style near base. Ninth sternite with a conspicuous oval lobe on either side of midline, this clothed with abundant long coarse setae.

**Tipula (Yamatotipula) catawbiana** sp. nov.

Allied to *iroquois;* general coloration light gray, the praescutum with four darker gray stripes that are narrowly bordered by blackish; antennal scape yellow; pleura uniformly gray; legs black, the femoral bases broadly yellow; wings with a brownish yellow tinge, sparsely patterned with darker; abdominal tergites brownish black, the caudal borders of the segments very narrowly paler; male hypopygium with the tergite produced into two divergent lobes that are narrower than the notch between them, the lobes set with abundant black setae; inner dististyle with beak very slender, much narrower than a strong outer arm that bears five or six strong spines along its posterior border.

♂. Length about 10 mm.; wing, 12 mm.; antenna, about 3.7 mm.

Frontal prolongation of head light gray; nasus distinct; palpi brownish black. Antennae with scape yellow; pedicel brownish yellow; flagellum black; flagellar segments only weakly incised; terminal segment reduced to a tiny cone. Head brownish gray, the front light gray; center of vertex glabrous and darker brown.

Pronotum buffy gray; pretergites yellow. Mesonotal praescutum light gray with four darker gray stripes that are very narrowly bordered by blackish, more heavily and distinctly so along the mesal edges of the intermediate pair; scutal lobes dark brownish gray, continued across the posterior portion of median area, the cephalic portion of the latter, adjoining the suture, light gray; scutellum and mediotergite gray, the parascutella darker. Pleura light gray, variegated on ventral anepisternum, ventral sternopleurite, meron, pteropleurite and pleurotergite with darker gray, without yellow areas; dorsopleural membrane buffy. Halteres brownish yellow, the knobs obscure yellow. Legs with the coxae gray pruinose; trochanters yellow; femora black, with less than the proximal half yellow; tibiae and tarsi black; claws (male) with a minute erect spine before midlength. Wings (Fig. 5) with a brownish yellow ground, the prearcular and costal fields clearer yellow; weak brown seams at wing-tip, along anterior cord, and as seams and washes on some of the veins, especially those beyond cord and the distal portion of *Cu;* veins brown, paler in the flavous areas. Venation: *Rs* approximately twice *m-cu;* cells *1st* $M_2$ short; *m-cu* on $M_{3+4}$ before fork.

Abdominal tergites brownish black, the caudal borders of the segments very narrowly and insensibly paler, more conspicuously so on outer segments; sternites yellow, the caudal borders a trifle darker, especially medially; hypo-

pygium dark, the appendages somewhat brighter. Male hypopygium (Fig. 6) with the tergite, *9t*, produced medially into two divergent lobes that are narrower than the U-shaped notch separating them, each lobe with abundant black setae. Outer dististyle, *od*, moderately long and narrow, pale, the apex obtuse. Inner dististyle, *id*, complex, the beak very slender, much narrower than a powerful outer arm bearing five or six strong spines along its posterior margin before the apical spine; between the beak and this outer arm a more slender glabrous spine and a smaller spinule just above the sensory group. Blades of gonapophyses elongate.

*Holotype*, ♂, Indian Gap, 5,500 ft., along small stream in coniferous forest, June 9, 1939 *(C. P. Alexander)*. Paratypes, 1 ♂, Mt. Mitchell, North Carolina, 5,500 ft., June 6, 1940, 1 ♂, 6,000 ft., June 7, 1940, ♂, Forney Ridge, Smokies, North Carolina, 6,000-6,100 ft., June 18, 1940 *(C. P. Alexander)*.

*Tipula (Yamatotipula) catawbiana* is readily told from *T. (Y.) iroquois* Alexander by the structure of the male hypopygium. Besides the characters listed and figured for the two species, the present fly lacks the conspicuous setiferous lobes on the ventral aspect of the ninth sternite found in *iroquois*. The latter species has the antennae uniformly darkened, including the scape and pedicel.

**Tipula (Yamatotipula) nephophila** sp. nov.

Allied to *iroquois;* general coloration gray, the praescutum with four slightly darker gray stripes that are insensibly bordered by darker; antennae with basal two segments yellow; knobs of halteres dark brown; femora obscure yellow basally, passing into brownish black; wings brownish yellow, the apex darkened; male hypopygium with the tergal lobes yellow, separated by a U-shaped notch, only weakly setiferous; inner dististyle a broad compressed plate, the beak unusually short and blackened; base of style on outer margin with a powerful curved smooth spine, on its concave face with microscopic setulae.

♂. Length about 11-12 mm.; wing, 13-13.5 mm.; antenna, about 4.7 mm.

Frontal prolongation of head brownish gray; nasus elongate; palpi brownish black. Antennae with scape and pedicel yellow, flagellum black; flagellar segments moderately incised. Head gray; anterior vertex broad.

Pronotum and pretergites obscure yellow. Mesonotal praescutum gray with four only slightly differentiated dark gray stripes that are insensibly bordered by darker, the humeral region lighter gray; scutal lobes gray, bordered by darker, the median area abruptly obscure yellow; scutellum pale brown, parascutella darker brown; postnotum gray. Pleura obscure yellow, variegated with gray, the latter areas on the anepisternum, ventral sternopleurite and meral region. Halteres yellow, the knobs dark brown. Legs with the coxae and trochanters pale yellow, not or scarcely pruinose; femora obscure yellow basally, with less than the distal half brownish black; tibiae brown to brownish black; tarsi black; claws long, with a minute tooth at near midlength. Wings (Fig 7) brownish yellow, the prearcular field clearer yellow, the costal region less

evidently so; stigma dark brown; wing-tip narrowly infuscated; cord and distal portion of vein *Cu* narrowly seamed with brown; veins dark brown, brighter in the more yellowish fields. Venation: *Rs* about one-half to two-thirds longer than *m-cu*.

Abdominal tergites brownish black, narrowly bordered laterally and caudally with pale; sternites pale yellow, the outer segments brownish black, narrowly bordered caudally with pale; hypopygium, excepting the appendages, blackened. Male hypopygium (Fig. 8) with the tergite, *9t*, produced apically into a yellow plate that bears a U-shaped median notch, the lateral lobes thus formed subequal in width to the diameter of the notch; armature of lobes very sparse, reduced to slender setae so that a general subglabrous appearance is produced. Outer dististyle, *od*, relatively broad, the apex little-produced, obtuse. Inner dististyle, *id*, with the beak unusually short, heavily blackened and obtuse, the body of the style a broadly compressed plate with sparse scattered setae; at base of style on outer margin a powerful curved smooth spine, on its concave face with microscopic setulae.

*Holotype*, ♂, Silers trail, 6,000 ft., June 6, 1939, along small stream in coniferous forest. *Paratypes*, 1 ♂, Alum Cave trail, Mount Leconte, 5,800 ft., June 12, 1939, along small mountain stream in coniferous forest *(C. P. Alexander)*; 4 ♀♀, Leconte, 6,000 ft., June 26-28, 1940; 5 ♂♀, Linville Falls, North Carolina, 3200 ft., June 3, 1940 *(C. P. Alexander)*.

*Tipula (Yamatotipula) nephophila* is amply distinct from all members of the *iroquois* group. It is most similar to *T. (Y.) catawbiana* sp. n. and *T. (Y.) succincta* Alexander, differing most evidently in the quite distinct male hypopygium. The specific name is an allusion to the Great Smoky Mountains.

*Tipula (Yamatotipula) calopteroides* Alexander, 1919 (*antiopa* Dietz, 1921).—Chimneys Camp, near entrance, along wet swale, 2,600 ft., June 16.

*Tipula (Yamatotipula) noveboracensis* Alexander, 1919. — Greenbrier, 2,000 ft., April 22 *(Williams)*; Middle Prong of the Little Pigeon River, 1,800 ft., June 7.

*Tipula (Yamatotipula) furca* Walker, 1848 (*bella* Loew, 1863).—Park near Gatlinburg, May 1, 1938 *(Williams)*.

*Tipula (Yamatotipula) cayuga* Alexander, 1915.—Anakeesta Ridge, 3,500 -3,700 ft., June 5; Chimneys Camp, 2,700 ft., June 9; Cades Cove, 2,200 ft., June 17 *(M. M. Alexander)*.

*Tipula (Yamatotipula) tephrocephala* Loew, 1864.—Indian Gap, 5,200 ft., June 10 *(Cole & Hickman)*; Leconte, Huffs Spring, 6,400 ft., June 11 *(Mrs. J. Huff)*; Anakeesta Ridge, 4,700 ft., June 5-8 *(W. H. Harrison)*.

*Tipula (Tipula) cunctans* Say, 1834.—Park boundary, near Sevierville, October 23, 1938 *(Williams)*.

**Tipula (Arctotipula) williamsiana** sp. nov.

Size large (wing, 20 mm. or more); general coloration gray, the praescutum with four conspicuous dark brownish gray stripes; antennae with flagellar segments strongly binodose; wings brownish gray, restrictedly patterned with more

whitish areas; macrotrichia lacking on veins of outer medial field; *Rs* from one-half to two-thirds its length longer than *m-cu;* abdomen reddish brown, with a conspicuous median dark stripe on both tergites and sternites; male hypopygium of very simple construction; ninth tergite large, the dorsal surface covered with abundant short black setulae; inner dististyle of simple form, blackened; ovipositor with cerci long and slender, their margins smooth.

♂. Length about 15-16 mm.; wing, 20-23 mm.; antenna, about 6 mm.

♀. Length about 21-23 mm.; wing, 23-26 mm.; antenna, about 5 mm.

Frontal prolongation of head relatively short, gray; nasus stout; palpi black. Antennae with scape and pedicel obscure yellow; flagellum bicolored, the basal enlargement dark brown, the remainder yellow; flagellar segments very strongly binodose, especially in male, the basal enlargement unusually conspicuous, larger than the outer swelling; verticils long and conspicuous, exceeding the segments in length. Head brownish gray, the front and orbits more buffy gray; a capillary brown median vitta; setigerous punctures darkened, conspicuous.

Pronotum gray, with a narrow dark brown median line. Mesonotal praescutum brownish gray, with four conspicuous, dark brownish gray stripes that are insensibly bordered by darker brown; extreme cephalic portion of praescutum with a further capillary median darkening; vestiture of praescutum pale and delicate; scutum brownish gray, each lobe with two brown areas; posterior sclerites of notum dark brownish gray. Pleura gray, more yellowish gray on dorsal sternopleurite and ventral pleurotergite; dorsopleural membrane buffy; groups of conspicuous setae on anepisternum and dorsal sternopleurite. Halteres with stem yellow, knob dark brown. Legs with coxae gray, with conspicuous setae; trochanters obscure yellow, darkened apically beneath; femora obscure yellow, the tips blackened, the amount subequal on all legs; tibiae brown, the tips blackened; tarsi black; claws small, simple. Wings (Fig. 9) brownish gray, restrictedly patterned with more whitish areas, including brightenings before and beyond the darker brown stigma; vague but evident whitened areas at near one-third the length of cell *Cu* and again before outer ends of cells *M* and *Cu;* certain of the veins, especially *Cu, m-cu, Rs* and outer radial veins narrowly seamed with brown; cell *Sc* yellowish brown; veins brown. Macrotrichia of veins beyond cord very sparse, entirely lacking in medial field; a relatively complete series of small trichia on outer section of $R_{4+5}$. Venation: $R_{1+2}$ strongly preserved; *Rs* from about one-half to two-thirds its length longer than *m-cu;* cell *1st* $M_2$ long, vein $M_3$ beyond it strongly arcuated on basal half; *m-cu* long so cell $M_4$ at base is slightly wider than at margin; *m-cu* at fork of $M_{3+4}$.

Abdominal tergites reddish brown, with a conspicuous median brownish black vitta, continuous on basal segments, narrowly interrupted on posterior borders of outer segments; sublateral stripes less evidently darkened, lateral margins grayish; sternites with a similar, very conspicuous median vitta, more or less interrupted at the paler posterior portions of the segments. Male hypopygium (Fig. 13) small, reddish brown, of unusually simple structure. Ninth tergite, *9t,* very small, the caudal border with a small U-shaped median notch, the lateral lobes with their apical margin sinuous; dorsal surface of tergite with

abundant short black setulae; ventral surface with a short black point on either side of median notch. Basistyle with outer apical angle produced into a short spinous point. Outer dististyle, *od*, a flattened ear-shaped structure, when flattened on a slide becoming slightly pointed at apex. Inner dististyle, *id*, of simple structure, the outer margin with scanty setae. Ovipositor with the cerci long and slender, blackened, the margins smooth.

*Holotype*, ♂, Rich Mountain, near Cades Cove, Tennessee, along stream, 1,950 ft., March 15, 1939 *(I. W. Williams)*. *Allotopotype*, ♀, with the type. *Paratopotype*, 1 ♀, with the type. *Paratypes*, 1 ♂, 2 ♀♀, Greenville, South Carolina, March 14, 1931; 3 ♀♀, altitude 950 ft., February 26, 1933 *(H. K. Townes)*; 1 ♂, Greenville Co., April 9, 1932 *(J. S. Rogers)* No. 1303.

I take unusual pleasure in naming this species in honor of Dr. Inez W. Williams, who has added most materially to our knowledge of the Tipulidae of the Great Smokies. I am referring this conspicuous fly to the subgenus *Arctotipula* Alexander, although the structure of the ovipositor is not typical of this group. Superficially the species resembles *Tipula (Vestiplex) carolinensis* Alexander, which is actually an entirely different fly. The present insect is evidently on the wing only in early spring. In June 10, 1939, I found a single wing of this species caught in a spider's web on the bridge spanning the small

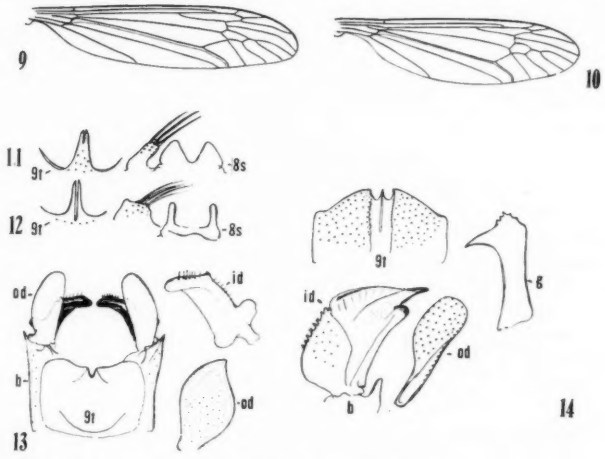


Fig. 9. *Tipula (Arctotipula) williamsiana* sp.n.; venation.
10. *Tipula (Oreomyza) coleana* sp.n.; venation.
11. *Tipula (Lunatipula) triplex linearis* subsp.n.; male hypopygium.
12. *Tipula (Lunatipula) triplex triplex* Loew; male hypopygium.
13. *Tipula (Arctotipula) williamsiana* sp.n.; male hypopygium.
14. *Tipula (Oreomyza) coleana* sp.n.; male hypopygium.
(*Symbols: b*, basistyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite.)

creek on Rich Mountain where the types had been taken earlier by Miss Williams.

*Tipula (Schummelia) hermannia* Alexander, 1915 (*fasciata* Loew, 1863). —Indian Gap, 5,300-5,500 ft., June 9; Anakeesta Ridge, 4,000-4,500 ft., June 6-8; Chimneys Camp, 2,700 ft., June 4; Greenbrier, May 15, 1938 *(Williams);* May 20 *(Williams);* Brushy Mt. trail, 2,500 ft., May 7 *(Cole);* Cades Cove, April 24, 1938 *(Williams).*

*Tipula (Schummelia) friendi* Alexander, 1940.— Anakeesta Ridge, 4,500 ft., June 8; Leconte, Alum Cave trail, 4,600-5,500 ft., June 12, common; Leconte Lodge, 6,400 ft., July 7 *(Mrs. J. Huff);* Greenbrier, Brushy Mt. trail, 2,500-4,500 ft., June 15; 3,500 ft., September 16 *(Cole & Hickman).*

The description of this novelty is to appear in the forthcoming "Diptera of Connecticut" which has been delayed in publication for several years. The fly is amply distinct from *hermannia,* especially in the structure of the male hypopygium. This latter has the median blade of the tergite smaller, subtended by long, slender spines. Posterior appendage of inner dististyle with a blackened tooth-like projection separated from the main body of the appendage by a U-shaped notch. In the Canadian zone of Mount Leconte it proved to be one of the commonest and most characteristic flies.

*Tipula (Oreomyza) fragilis* Loew, 1863.—Leconte Lodge, 6,400 ft., September 1-9 *(Mrs. J. Huff);* Park, near Gatlinburg, October 23, 1938 *(Williams).*

*Tipula (Oreomyza) ignobilis* Loew, 1863.—Chimneys Camp, 2,700 ft., June 17, at light *(Cole & Hickman);* Greenbrier, 2,500 ft., May 22, 1938 *(Williams).*

*Tipula (Oreomyza) trivittata* Say, 1823.—Chimneys Camp, 2,700 ft., June 10; June 17, at light *(Cole & Hickman);* Greenbrier, 2,500 ft., May 15-22, 1938 *(Williams).*

*Tipula (Oreomyza) entomophthorae* Alexander, 1918 (*similissima* Dietz, 1921).—Indian Gap, 5,200 ft., June 10 *(Cole & Hickman);* Leconte Summit, 6,590 ft., June 13 *(W. H. Harrison).*

*Tipula (Oreomyza) margarita* Alexander, 1918.—Greenbrier, 2,500 ft., May 7 ,1939 *(Cole).* This rare fly had hitherto been known only from New York and Ohio.

**Tipula (Oreomyza) angulata cherokeana** subsp. nov.

♂. Length, about 13-14 mm.; wing, 15-16.5 mm.; antenna, about 4 mm.

Characters as in typical *angulata* Loew (Northeastern North America), differing as follows: Antennae shorter, approximately two-thirds as long as in typical form, bicolored. Wings with petiole longer and narrower; white band beyond stigma and cord much wider, its outer edge lying beyond the outer end of cell *1st* $M_2$. Venation: Cell *1st* $M_2$ shorter, the cephalic face (second section of vein $M_{1+2}$) gently arcuated. Male hypopygium with details of structure distinct. Ninth tergite with the median notch narrow, with a small

median point at its base. Blade of outer dististyle more widely expanded, the greatest width opposite the base of blade. Inner dististyle with apical beak more obtusely rounded;lobe at base of outer face of style blackened and bearing a separate cylindrical lobule. Gonapophyses appearing as slender rods, the tips decurved acute spines. In *angulata*, the apophyses appear as flattened pale blades that narrow gradually to a small apical point.

*Holotype*, ♂, Brushy Mountain trail, 4,300 ft., June 15, 1939 *(A. C. Cole)*, caught while flying over trail near Trillium Gap. *Paratype*, a badly damaged ♂, Mount Mitchell, North Carolina, Bald Knob Ranger Station, 5,200 ft., June 22, 1939 *(C. P. Alexander)*.

I am placing this as a southern race of *angulata* but believe that more material will validate it as a species.

**Tipula (Oreomyza) coleana** sp. nov.

Allied to *angulata;* general coloration gray, the praescutum with four more brownish stripes; wings whitish subhyaline, heavily patterned with brown; cells *C* and *Sc* more yellowish brown; an incomplete white fascia beyond stigma and cord; $R_{1+2}$ entire; abdominal tergites obscure yellow, trilineate with brown; male hypopygium with the caudal margin of tergite convexly rounded, with a median notch that bears an acute spine; dorsal surface of tergite with a yellow median furrow; inner dististyle with the basal lobe irregularly fimbriate along outer margin; gonapophyses heavily blackened, at apex produced laterad into a powerful acute spine.

♂. Length, about 12.5-13 mm.; wing, 14-15 mm.

Frontal prolongation of head yellow above, including nasus, a little darker on ventral half; palpi dark brown. Antennae with scape and pedicel light yellow; flagellum broken. Head light gray, more buffy in front; a capillary darkened median brown vitta.

Pronotum pale brownish gray, with a brown median vitta. Mesonotal praescutum gray with four more brownish gray stripes, the intermediate pair more distinct; scutal lobes weakly darkened, the median area grayish; scutellum brownish gray, with a capillary dark brown median line; mediotergite gray. Pleura brownish yellow, sparsely pruinose, sparsely variegated with darker areas, dorsopleural membrane clearer yellow. Halteres with stem white, knob brownish black. Legs with coxae pale yellow, sparsely pruinose; trochanters yellow; femora obscure brownish yellow, the tips darker; tibiae brown, darker at tips; tarsi black. Wings (Fig. 10) with the ground color whitish subhyaline, heavily patterned with brown; prearcular field and cells *C and Sc* more yellowish brown; an incomplete but conspicuous white fascia beyond stigma and cord, extending from costa to near midlength of cell $M_4$, including virtually all of cell *1st* $M_2$; ground areas before cord extensive and clearly delimited; cell $Cu_1$ uniformly darkened; veins dark brown, paler in the ground areas and costal field. Venation: Tip of $R_{1+2}$ preserved but pale and without trichia; basal section of $R_{4+5}$ reduced; petiole of cell $M_1$ a little exceeding the cell itself.

Abdominal tergites obscure yellow, the first segment clearer yellow; three

narrow but conspicuous brown stripes, the median one entire or virtually so, the sublateral pair interrupted by the gray lateral and posterior borders of the segments; sternites pale brown, darker medially; hypopygium of moderate size, black. Male hypopygium (Fig. 14) with the caudal margin of tergite, *9t*, convexly rounded, with a conspicuous median furrow and apical notch, the latter bearing an acute point that extends caudad to the level of the remainder of tergite; median furrow yellow, contrasting with the dark brown remainder of tergite, with a median carina extending cephalad from the apex of the median spine; lateral tergal shoulders low. Outer dististyle dusky, appearing as a flattened club, the stem narrow. Inner dististyle, *id*, with a conspicuous blackened basal lobe or flange, the outer margin with blackened tubercles that bear conspicuous setae to produce a fimbriate appearance; apical beak slender, blackened. Gonapophyses, *g*, heavily blackened, expanded into a head at apex, the latter produced at a right angle into a powerful acute spine.

*Holotype*, ♂, Mount Leconte, near Leconte Lodge, 6,400 ft., September 3, 1939 *(Mrs. J. Huff)*. *Paratype*, ♂, Ramsey Fork, Greenbrier Cove, 1,900 ft., July 14, 1939 *(A. C. Cole)*.

I am very pleased to dedicate this species to Dr. Arthur C. Cole, of the University of Tennessee, who has aided most materially in the present survey of the Tipulidae of the Smokies. The fly is most nearly related to *Tipula (Oreomyza) angulata* Loew, differing most conspicuously in the structure of the male hypopygium, notably the tergite, inner dististyle and gonapophyses.

*Tipula (Oreomyza) penobscot* Alexander, 1915.—Indian Gap, 5,600 ft., June 9; Leconte, Huffs Lodge, 6,400 ft., July 21 *(Mrs. J. Huff)*; Rainbow trail, 5,500 ft., June 13 *(W. H. Harrison)*. This small species occurred only in the spruce-fir forests where it was rare. Previously it had not been recorded from south of Pennsylvania.

*Tipula (Oreomyza) senega* Alexander, 1915 (*pallida* Loew, 1863).—Indian Gap, 5,300-5,500 ft., June 9; in spruce-fir forests and beech gap association; Silers trail, 6,200 ft., June 6. This is another species that had not been recorded from the southern Appalachians.

*Tipula (Lunatipula) apicalis* Loew, 1863.—Leconte, Alum Cave trail, 5,100 ft., June 12; Greenbrier, 2,500 ft., May 20 *(Williams)*; 2,500 ft., *(W. H. Harrison)*.

*Tipula (Lunatipula) monticola* Alexander, 1915.—Indian Gap, 5,300 ft., June 9. In the coniferous forests of the Canadian zone; hitherto not recorded from south of Pennsylvania.

**Tipula (Lunatipula) valida atricornis** subsp. nov.

Very close to the typical form but much darker, especially the antennae and wings. Antennal flagellum beyond the first segment uniformly blackened or with the basal enlargement only a trifle darker than the apical pedicel of the segment. Wings heavily patterned, especially at and beyond cord, leaving major areas of the ground along the cord, beyond the stigma, and in cells $R_5$ and the basal medial cells.

*Holotype*, ♂, Leconte Lodge, 6,400 ft., June 21 *(Mrs. J. Huff)*.

*Allotype and paratypes*, several of both sexes, with the type, June 21-August 12, 1939 *(Mrs. J. Huff)*; Newfound Gap, North Carolina, resting on cliffs, 5,000 ft., June 5; 1 ♀, Myers Lodge, Cades Cove, 1,900 ft., June 10 *(M. M. Alexander)*.

Although this fly differs from the typical form of northeastern North America only in details of coloration, I feel that it should be distinguished by a subspecific name. It is one of the largest and most conspicuous crane-flies within the Park area.

*Tipula (Lunatipula) duplex* Walker, 1848 (*mingwe* Alexander, 1915).—Chimneys Camp, July 2-18 *(A. C. Cole)*; Greenbrier, Brushy Mt. trail, 3,500-4,500 ft., July 11 *(A. C. Cole)*.

*Tipula (Lunatipula) umbrosa* Loew, 1863.—Chimneys Camp, 2,700 ft., June 4; Gatlinburg, May 1, 1938 *(Williams)*; Greenbrier, 1,800-2,500 ft., June 15; Cades Cove, April 24, 1938 *(Williams)*.

**Tipula (Lunatipula) triplex linearis** subsp. nov.

♂. Length, about 20 mm.; wing, 20 mm.; antenna, about 6.2 mm.

Differs from the typical form chiefly in hypopygial features. Male hypopygium (Fig. 11) with the median lobe of tergite, *9t*, narrow, strongly produced, the incision linear and unusually short, extending back from the tip of lobe for only about one-third the length of latter. Eighth sternite, *8s*, with the lateral lobes unusually long and conspicuous; submedian lobes very broad, subtriangular in outline, the surface microscopically corrugated.

In typical *triplex* Walker (*inermis* Doane) of northeastern North America, the male hypopygium (Fig. 12) has the median lobe of tergite, *9t*, very deeply split, the incision extending cephalad to beyond the bases of the lobes, the tergal spines thus formed very slender. Eighth sternite, *8s*, with the lateral lobes very stout, the setae numerous, arising from the mesal portion of the lobe; submedian lobes very slender, almost parallel-sided, their surface smooth.

*Holotype*, ♂, Greenbrier Cove, 2,000 ft., May 15, 1938 *(I. W. Williams)*.

There is still much difficulty in defining the various species and forms of members of the *triplex* group. The shape of the submedian lobes of the eighth sternite of the present fly is much as in the otherwise distinct *T. (L.) flavoumbrosa* Alexander and it will probably have to be removed from its present assigned position when more material becomes available.

*Tipula (Lunatipula) submaculata* Loew, 1863.—Silers trail, 6,000 ft., June 6; Leconte, Huffs Lodge, 6,400 ft., July 21 *(Mrs. J. Huff)*; Cades Cove, May 8, 1939 *(Williams)*.

*Tipula (Lunatipula) mallochi* Alexander, 1920.—Greenbrier, 2,500 ft., May 22, 1938 *(Williams)*.

*Tipula (Lunatipula) translucida* Doane, 1901.—Brushy Mt. trail, Greenbrier, 2,000 ft., June 15.

*Tipula (Lunatipula) tuscarora* Alexander, 1915.—Greenbrier, May 20 *(Williams);* Brushy Mt. trail, 2,200 ft., June 15.

*Dolichopeza (Dolichopeza) americana* Needham, 1908.—Leconte, Huffs Lodge, 6,400 ft., June 12-13; Alum Cave trail, 4,500-6,000 ft., June 12; Greenbrier, 2,400 ft., May 7 *(Williams),* 1,800-1,900 ft., June 7; Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman).*

*Dolichopeza (Oropeza) carolus* Alexander, 1940 (*albipes* Johnson, 1909). —Greenbrier, 1,800 ft., June 7; Cades Cove, Myers Lodge, 2,000 ft., June 17 *(M. M. Alexander).*

*Dolichopeza (Oropeza) walleyi* Alexander, 1931.—Indian Gap, 5,300-5,500 ft., June 9; 4,800 ft., June 17 *(Cole & Hickman);* Leconte, Alum Cave trail, 5,800 ft., June 12; Chimneys Camp, 2,700 ft., in rock-houses behind camp, June 5-10; Greenbrier, 1,800 ft., June 7; Brushy Mt. trail, 3,500 ft., June 15.

**Dolichopeza (Oropeza) subvenosa** sp. nov.

Allied to *venosa;* mesonotal praescutum grayish yellow with three conspicuous blackish stripes; pleura grayish yellow, variegated with brown; tips of tibiae and the tarsi paling to yellow, femoral tips narrowly brightened; wings with a strong brownish tinge; stigma darker brown, with conspicuous cream-colored post-stigmal areas; male hypopygium with the inner dististyle broad, especially opposite its outer end; aedeagus with a strong spine on ventral face near apex.

♂. Length, about 9-11 mm.; wing, 11-12.5 mm.; antenna, about 3-3.3 mm.

♀. Length, about 11 mm.; wing, 11 mm.

Frontal prolongation of head pale testaceous; palpi brown. Antennae with scape and pedicel pale yellow; base of first flagellar segment pale, the remainder black; segments relatively long, subcylindrical, much exceeding the erect verticils; pubescence of segments short. Head brownish gray, darker in central portion.

Pronotum brown, blackened medially. Mesonotal praescutum grayish yellow, with three conspicuous blackish stripes, the posterior interspaces obscured; scutal lobes brownish black, the median area very restrictedly paler; posterior sclerites not black or brownish black. Pleura grayish yellow, variegated with brown on the anepisternum, ventral sternopleurite, meron and extreme ventral edge of pleurotergite. Halteres elongate, stem yellow, knob darkened. Legs with coxae pale, the fore pair darker; trochanters yellow; femora blackened, the tips narrowly pale; tibiae dark brown, paling to obscure yellow on distal portion; tarsi obscure yellow. Wings (Fig. 15) with a strong brownish tinge; stigma oval, dark brown; a conspicuous, paler brown seam along vein *Cu;* membrane adjoining the stigma, especially in cells beyond the stigma, cream-yellow; a restricted brightening across the fork of *M;* veins brown. Venation: $Sc_2$ ending opposite or just beyond origin of *Rs.*

Abdominal segments blackened medially and on basal rings of segments, leaving extensive yellow areas on sides of posterior rings; outer sternites and tergites, including hypopygium, more uniformly blackened. Male hypopygium

(Fig. 18) with the lateral arms of tergite, *9t*, blackened, the apices dilated into oval spatulate blades, the margins smooth or without conspicuous angulations; median area of tergite trilobed, the central lobe longer and more spinous. Outer dististyle, *od*, uniformly blackened, cylindrical, a little exceeding the inner style. Inner dististyle, *id*, much deeper than in *venosa*, elevated just above the short apical beak. Gonapophyses, *g*, much as in *venosa*, appearing as blackened spines, their bases with conspicuous setae. Aedeagus, *a*, close to apex on ventral face with a strong erect spine, this variable in length but always strongly developed. In *venosa*, the lateral arms of tergite are more angular, the median area of the caudal margin with the central lobe low or lacking; inner dististyle narrower, especially above and before the apical beak; aedeagus without spine.

*Holotype*, ♂, Anakeesta Ridge, 4,500 ft., June 12, 1939 *(C. P. Alexander)*. *Allotopotype*, ♀, 4,000 ft., June 5, 1939. *Paratypes*, ♂, Indian Gap, 4,500 ft., June 17 *(Cole & Hickman)*; Anakeesta Ridge, 4,000-4,500 ft., June 7-12, 1939; Forney Ridge, 5,800-6,300 ft., June 18-19, 1940; Leconte trail,

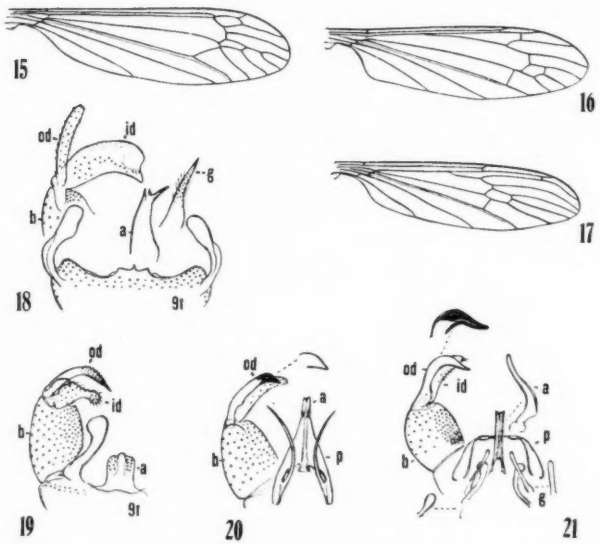


Fig. 15. *Dolichopeza (Oropeza) subvenosa* sp.n.; venation.
16. *Antocha (Antocha) biarmata* sp.n.; venation.
17. *Dicranoptycha acanthophallus* sp.n.; venation.
18. *Dolichopeza (Oropeza) subvenosa* sp.n.; male hypopygium.
19. *Dicranoptycha acanthophallus* sp.n.; male hypopygium.
20. *Antocha (Antocha) biarmata* sp.n.; male hypopygium.
21. *Antocha (Antocha) decurvata* Alexander; male hypopygium.
(*Symbols:* *a*, ædeagus; *b*, basistyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite.)

5,000 ft., June 13, 1939 *(W. H. Harrison);* Greenbrier, Brushy Mt. trail, 2,500-3,500 ft., June 15; Gregory Ridge trail, 2,500 ft., June 17, 1939 *(C. P. Alexander);* North Carolina, Bald Knob Ranger Station, Mt. Mitchell, 5,200 ft., June 22, 1939 *(C. P. Alexander);* Mt. Mitchell, 4,000-5,000 ft., June 7, 1940.

Common and wide-spread, especially in the zone of spruce and fir, but also in the hemlock forests of the Transition zone. The fly is readily told from its nearest ally, *Dolichopeza (Oropeza) venosa* (Johnson, 1909) by the details of coloration of the body and wings, and by the structure of the male hypopygium, especially of the ninth tergite, inner dististyle and aedeagus, as discussed above. This is the most common and characteristic member of the subgenus at high altitudes in the Great Smokies.

*Dolichopeza (Oropeza) obscura* (Johnson, 1909).—Leconte, Alum Cave trail, 5,000 ft., June 12; Greenbrier, 2,500 ft., May 20 *(Williams),* 1,800 ft., June 7; Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman),* an unusually late record; Cades Cove, Myers Lodge, 1,900 ft., June 10.

*Dolichopeza (Oropeza) tridenticulata* Alexander, 1931.—Greenbrier, 1,850 ft., June 7; 2,500 ft., June 15; Cades Cove, 1,900 ft., June 10 *(M. M. Alexander).*

*Dolichopeza (Oropeza) subalbipes* (Johnson, 1909).—Greenbrier, Brushy Mt. trail, 2,000-4,800 ft., the latter at Piney Heath on Brushy Mt., June 15.

### Cylindrotominae

*Liogma nodicornis flaveola* Alexander, 1919.—Silers trail, 6,000-6,500 ft., June 6; Indian Gap, 5,300-5,500 ft., June 9 *(Cole & Hickman);* Anakeesta Ridge, 4,500 ft., swept from beds of *Diphylleia cymosa,* June 5-8; Leconte Lodge, 6,400 ft., June 12-13; Greenbrier, May 15, 1938, May 7-20 *(Williams),* Brushy Mt. trail, 3,500 ft., June 15.

### Limoniinae

#### Limoniini

**Antocha (Antocha) biarmata** sp. nov.

General coloration buffy to light brown, the cephalic portion of praescutum narrowly dark brown; antennae black; halteres yellow, knobs brown; legs brownish black; wings whitish subhyaline, the prearcular field milky white; abdomen brown, the subterminal segments black; male hypopygium with the blackened apex of outer dististyle very small; phallosome with a single pair of developed spines, the outer pair very reduced to atrophied.

♂. Length, about 5-6 mm.; wing, 5.5-7 mm.

♀. Length, about 6.5-7 mm.; wing, 6.5-7 mm.

Rostrum light brown; palpi black. Antennae black, short; flagellar segments subglobular to short-oval, the outer segments a little longer. Head uniformly gray.

Thorax buffy to light brown, with the cephalic portion of the median

praescutal area narrowly darker brown, the posterior portion and the lateral stripes paler, more reddish brown; posterior sclerites of notum brownish yellow to obscure yellow, especially the uniformly yellow scutellum. Pleura brownish yellow, the dorsopleural membrane paler. Halteres yellow, knobs brown. Legs with the coxae yellow to brownish yellow; trochanters yellow; remainder of legs dark brown to brownish black. Wings (Fig. 16) whitish subhyaline, the prearcular field more milky-white; stigma lacking; veins brown, *Cu* and *2nd A* somewhat darker; in prearcular field, veins white. Venation: Cell *1st* $M_2$ small.

Abdomen with tergites brown; sternites more yellowish brown; a subterminal black ring involving segments seven and eight; hypopygium obscure yellow. Male hypopygium (Fig. 20) with the blackened apex of the outer dististyle, *od*, unusually small, the shortest of any of the species in eastern North America. Phallosome, *p*, consisting of only two elongate slender spines, their tips acute; before apex of aedeagus a constriction or break with the subtending apophyses here produced into very small pale spines that are sometimes lost by atrophy.

*Holotype*, ♂, Greenbrier Cove, Tennessee, 1,680 ft., June 7, 1939 *(M. M. Alexander)*. *Allotopotype*, ♀, pinned with type, June 7. *Paratopotypes*, several ♂♀, 1,700-1,900 ft., June 7, 1939, June 22-23, 1940; *paratype*, 1 ♂, on microscope slide, McLean, Tompkins Co., New York, May 16, 1911 *(C. P. Alexander)*.

*Antocha (Antocha) biarmata* is most nearly related to *A. (A.) opalizans* Osten Sacken, among the described species. The male hypopygium of *A. (A.) decurvata* Alexander is shown for comparison. The present fly differs from all other regional species in the structure of the male hypopygium, especially the small blackened head of the outer dististyle and the presence of a single pair of developed spines on the phallosome. The species was very common on stones at the edge of the water of the Middle Prong of the Little Pigeon River, near the Fork of Porters Creek. It was associated with a species of *Blepharocera* and with another crane-fly, *Limonia (Limonia) simulans* (Walker).

*Dicranoptycha sobrina* Osten Sacken, 1859.—Leconte Summit, 6,590 ft., June 12; Chimneys Camp, 2,700 ft., June 4-10; Greenbrier, May 15-22, 1938 *(Williams)*; Brushy Mt., 3,000 ft., May 20 *(Williams)*.

**Dicranoptycha acanthophallus** sp. nov.

General coloration dark gray, the praescutal stripes only feebly differentiated; femora yellow, the tips narrowly infuscated, the amount subequal on all legs; wings with the ground color brownish yellow, the prearcular and costal fields clearer yellow; a distinct brown seam along vein *Cu* for the entire length of wing; abdomen black, hypopygium obscure yellow; male hypopygium with lateral tergal arms broadly expanded at tips; outer dististyle with subappressed spinules on distal third, the apex along straight spine; inner dististyle strongly constricted before apex; aedeagus massive, near apex with more than a score of erect spines.

♂. Length, about 8-8.5 mm.; wing, 9 mm.

♀. Length, about 11-12 mm.; wing, 9-11 mm.

Rostrum gray pruinose; palpi black. Antennae with scape black, sparsely pruinose; pedicel and basal flagellar segments brown, the outer flagellar segments black; flagellar segments long-oval. Head gray.

Mesonotum dark gray, the praescutum with scarcely differentiated blackish gray stripes; pseudosutural foveae black. Pleura dark gray, the dorsopleural membrane a little more obscure. Halteres pale yellow. Legs with coxae obscure yellow, the bases of fore pair a trifle darkened; trochanters yellow; femora yellow, the tips narrowly infuscated, the amount subequal on all legs; tibiae and basitarsi yellow, the tips narrowly darkened; terminal tarsal segments black. Wings (Fig. 17) with the ground color weakly brownish yellow, the prearcular and costal fields clear luteous; a distinct brownish seam along vein *Cu*, involving the adjoining portions of cells *M* and $M_4$ to margin, as well as the extreme base of cell *Cu;* veins brown, yellow in the flavous portions. Costal fringe (male) moderately long and dense. Venation: *Rs* subequal in length to cell *1st* $M_2$; *m-cu* variable in position, from close to fork of *M* to more than one-half its length beyond this fork.

Abdomen brownish black, more or less pruinose; hypopygium obscure yellow. Male hypopygium (Fig.19) with the tergal arms broadly expanded at tips into flattened spatulate blades. Outer dististyle, *od*, terminating in a long straight spine, before apex on distal third with abundant subappressed spinules on all faces. Inner dististyle, *id*, strongly expanded basally, constricted before the slightly dilated apex. Aedeagus, *a*, stout and massive, near apex provided with more than a score of conspicuous erect spines.

*Holotype*, ♂, Gregory Ridge Trail, 4,600 ft., June 17, 1939 *(C. P. Alexander). Allotopotype*, ♀, pinned with type. *Paratopotypes*, 7 ♀♀, with the types; *paratypes*, 1 ♀, Greenbrier Cove, 2,000 ft., June 15, 1939; ♂♀, 2,100 ft., June 23, 1940 *(C. P. Alexander)*. The types were picked from vegetation along the trail during heavy rains.

By my most recent key to the American species of *Dicranoptycha* (Dipt. Connecticut, Tipulidae; mss.), the present fly runs to couplet 4, disagreeing with all species beyond that point in the combination of spinulose outer dististyle and darkened femoral tips. It differs from all regional species in the structure of the male hypopygium, notably the spinulose aedeagus.

*Helius (Helius) flavipes* (Macquart, 1855).—Greenbrier, 2,000 ft., May 15, 1938 *(Williams)*.

*Limonia (Limonia) tristigma* (Osten Sacken, 1859).—Leconte, Huffs Lodge, 6,400 ft., July 30, August 5, September 7 *(Mrs. J. Huff)*.

*Limonia (Limonia) indigena* (Osten Sacken, 1859).— Silers trail, 5,800-6,200 ft., numerous, often resting on moss-covered trunks of trees, associated with *Epiphragma fascipennis* and *Dactylolabis hudsonica;* Indian Gap, 4,800 ft., June 17 *(Cole & Hickman);* Leconte, Alum Cave trail, 4,000-6,000 ft., June 12; Huffs Lodge, 6,400 ft., August 15 *(Mrs. J. Huff);* Chimneys Camp, 2,700 ft., June 4, in rock-houses behind camp; Greenbrier, May 7, 1939, May 15, 1938 *(Williams);* Brushy Mt. trail; 3,000-4,500 ft., June 15.

*Limonia (Limonia) macateei* (Alexander, 1916) (*varipes* Dietz, 1921).—Foot of trail to the Chimneys, 3,200 ft., June 18 *(W. H. Harrison)*, several flying above rotten log; Greenbrier, Brushy Mt. trail, 3,500 ft., June 15 *(Hickman)*.

*Limonia (Limonia) globithorax* (Osten Sacken, 1869).—Clingmans Dome, 6,000 ft., June 11; Leconte, Alum Cave trail, 6,000 ft., June 12; Huffs Lodge, 6,400 ft., September 7 *(Mrs. J. Huff)*; Chimneys Camp, 2,600 ft., June 16; Smoky Mt. Park, near Gatlinburg, October 23, 1938 *(Williams)*; Greenbrier, Brushy Mt. trail, 4,000 ft., June 15; 3,500 ft., September 16 *(Cole & Hickman)*.

*Limonia (Limonia) fusca* Meigen, 1804 (*pubipennis* Osten Sacken, 1859).—Silers trail, 5,800-6,000 ft., June 6; Indian Gap, 4,800 ft., June 17 *(Cole & Hickman)*; Anakeesta Ridge, 4,000-4,700 ft., June 5; Leconte, Alum Cave trail, 4,500-5,500 ft., June 12; Huffs Lodge, 6,400 ft., June 13; Greenbrier, May 15, 1938, May 7, 1939 *(Williams)*, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*; Cades Cove, April 24, 1938 *(Williams)*.

*Limonia (Limonia) simulans* (Walker, 1848).—Anakeesta Ridge, 4,000-4,200 ft., June 5, along wet cliffs; Chimneys Camp, 2,700 ft., July 26 *(Cole)*; Park, near Gatlinburg, October 23, 1938 *(Williams)*; Greenbrier, May 7, 1939 *(Williams)*.

*Limonia (Dicranomyia) divisa* Alexander, 1929 (*diversa* Osten Sacken, 1859).—Silers trail, 6,200 ft., June 6; Newfound Gap Highway, 3,500 ft., June 5; Indian Gap, 4,800 ft., June 17 *(Cole & Hickman)*; Leconte Summit, 6,590 ft., June 13; Greenbrier, May 7 *(Williams)*, June 7; Little River Gorge, 1,400 ft., on cliffs, June 10; Cades Cove, 1,900 ft., June 10 *(M. M. Alexander)*.

*Limonia (Dicranomyia) humidicola* (Osten Sacken, 1859).—Anakeesta Ridge, 4,000-4,500 ft., June 5-8; Little River Gorge, 1,400 ft., on wet cliffs, June 10.

*Limonia (Dicranomyia) liberta* (Osten Sacken, 1859).—Chimneys Camp, July 13 *(Cole)*; Greenbrier, May 7 *(Williams)*; Cades Cove, April 24, 1938 *(Williams)*.

*Limonia (Dicranomyia) morioides* (Osten Sacken, 1860).—Chimneys Camp, 2,700 ft., June 8; Greenbrier, 1,800 ft., June 7; Cades Cove, Myers Lodge, 1,900 ft., June 10.

*Limonia (Dicranomyia) spinifera* (Alexander, 1929).—Leconte, Huffs Lodge, 6,400 ft., September 7 *(Mrs. J. Huff)*; Greenbrier, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*.

*Limonia (Dicranomyia) gladiator* (Osten Sacken, 1859).—Greenbrier, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*.

*Limonia (Dicranomyia) pudicoides* Alexander, 1929.— Leconte, Rainbow trail, 3,500 ft., June 13, 1 ♀ ovipositing in wet moss along trail; Chimneys Camp, 2,600 ft., June 14, numerous around small waterfall along road; Little River Gorge, 1,400 ft., June 10, several on wet dripping cliffs, associated with *Limonia (Dicranomyia) humidicola* (Osten Sacken), *L. (Geranomyia)*

*diversa* (Osten Sacken), *Dolichopeza (Dolichopeza) americana* Needham and others. Most of these specimens had assumed the yellow color of aged specimens while those at the Chimneys were all of the pale green teneral coloration.

*Limonia (Dicranomyia) stulta* (Osten Sacken, 1859).—Chimneys Camp, 2,700 ft., June 4, not uncommon in rock houses behind the camp, in damp shaded woods; Greenbrier, 2,500 ft., May 15, 1938 *(Williams)*, 1,800 ft., June 7; Cades Cove, Myers Lodge, 1,900 ft., June 10-17 *(M. M. Alexander)*.

*Limonia (Dicranomyia) uliginosa* Alexander, 1929.—Leconte, Alum Cave trail, 6,000 ft., June 12, in patches of wet sphagnum moss on sloping cliffs with a sparse growth of *Leiophyllum Lyoni*, with a Carolina Junco nesting at this exact spot; boggy areas near Huffs Lodge, 6,400 ft., June 13. A characteristic bog-inhabitant, not before reported from south of New York and Michigan.

*Limonia (Geranomyia) diversa* (Osten Sacken, 1859).—Newfound Gap Highway, on wet cliffs, 3,300 ft., June 5; Gatlinburg, May 1, 1938 *(Williams)*; Little River Gorge, 1,300-1,400 ft., abundant on wet cliffs, June 10; Cades Cove, Gregory Ridge trail, 2,600 ft., June 17.

*Limonia (Geranomyia) rostrata* (Say, 1823).—Gatlinburg, May 1, 1938 *(Williams)*; Cades Cove, May 8, 1938 *(Williams)*.

*Limonia (Rhipidia) domestica* (Osten Sacken, 1859).— Leconte, Huffs Lodge, 6,400 ft., July 23 *(Mrs. J. Huff)*; Chimneys Camp, July 13 *(Cole)*; Gatlinburg, May 1, 1938 *(Williams)*; Greenbrier, 2,000 ft., May 15-22, 1938 *(Williams)*, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*; Cades Cove, May 8, 1938 *(Williams)*.

*Limonia (Rhipidia) fidelis* (Osten Sacken, 1859).—Greenbrier, May 15 *(Williams)*.

*Limonia (Rhipidia) maculata* (Meigen, 1818).—Chimneys Camp, 2,700 ft., July 26 *(Cole)*; Gatlinburg, May 1, 1938, October 23, 1938 *(Williams)*; Greenbrier, May 15, 1938 *(Williams)*, Brushy Mt. trail, September 16 *(Cole & Hickman)*; Cades Cove, April 24-May 8, 1938 *(Williams)*.

**Limonia (Rhipidia) maculata lecontei** subsp. nov.

As in the typical form but with the dark wing pattern very extensive, greatly reducing the pale ground color; the three major costal areas reach vein *M* behind and leave only small pale spots between them in the costal cell. In some specimens the dark pattern of the wing disk is so extensive that the ground dots become very small and scattered.

Antennae of male with segments four to ten, inclusive, with two short branches, the longest about one-half longer than the segments; terminal three segments simple. Femora darkened, on outer half brown, the darkened apical ring not or scarcely differentiated against this ground. Male hypopygium with six or seven rostral spines that are placed at near two-thirds the length of the prolongation. In typical *maculata*, these spines are at or immediately beyond midlength of the prolongation.

*Holotype*, ♂, Mount Leconte, Huffs Lodge, 6,400 ft., August 10, 1939 *(Mrs. J. Huff)*. *Allotopotype*, ♀, with type. *Paratopotypes* 5 ♂ ♀, July 16-August 8, 1939.

PEDICIINI

*Ula elegans* Osten Sacken, 1869.—Greenbrier, May 22, 1938; May 7, 1939 *(Williams)*; Cades Cove, May 24, 1938 *(Williams)*.

*Ula paupera* Osten Sacken, 1869.—Greenbrier, May 3, 1938 *(Williams)*.

*Pedicia (Pedicia) margarita* Alexander, 1929.—Leconte, Huffs Lodge, 6,400 ft., July 10, 16; August 2 *(Mrs. J. Huff)*.

This is the smallest and one of the rarest of our local species of the subgenus. It had not been recorded from south of New York and Massachusetts.

*Pedicia (Tricyphona) calcar* (Osten Sacken, 1859).—Silers trail, 6,000 ft., June 6; Leconte, Huffs Lodge, around spring in boggy areas, 6,400 ft., June 12-13.

**Pedicia (Tricyphona) huffae** sp. nov.

Allied to *autumnalis;* antennae (male) relatively elongate, 16-segmented; mesonotum and pleura conspicuously patterned with dark brown and yellow; knobs of halteres darkened; wings yellowish gray, the stigma oval, brown; wings of female virtually as large as those of male; cell $M_2$ open by atrophy of *m;* male hypopygium with the basistyle provided with long coarse setae; dististyle with five unequal spinous points.

♂. Length, about 13-15 mm.; wing, 12-14 mm.; antenna, 3.6-3.8 mm.

♀. Length, about 15-17 mm.; wing, 11-13 mm.; antenna, 2.3-2.5 mm.

Rostrum and palpi black. Antennae (Fig. 28, male) 16-segmented; scape and pedicel reddish brown, flagellum black; antennae of male unusually long for a member of this subgenus, as shown by the measurements; segments cylindrical, clearly delimited, clothed with a dense white pubescence; pedicel elongate, exceeding one-half the length of scape; antennae of female shorter than in male but still longer than in either sex of *autumnalis*. The antenna of *autumnalis* (male) is shown for comparison (Fig. 29). Head gray.

Pronotum obscure yellow, brownish gray medially. Mesonotal praescutum chiefly dark brown, sparsely pruinose; praescutal stripes in cases lacking or ill-defined, in other specimens the stripes separated and much more evident; scutal lobes darkened; scutellum obscure yellow; mediotergite brown or reddish, in cases lined medially and on sides by darker; pleurotergite chiefly darkened. Pleura yellow, variegated with brownish black on the anepisternum and sternopleurite; propleura and pteropleurite pale. Halteres with stem pale, knob darkened. Legs with coxae darkened on outer face; trochanters obscure yellow; femora brownish yellow, the tips narrowly dark brown; tibiae and basitarsi obscure yellow, the tips narrowly infuscated; remainder of tarsi brownish black. Wings (Fig 23) yellowish gray, the prearcular and costal portions clearer yellow; stigma oval, brown; veins dark brown. Wings of female not or but slightly smaller than those of male. Venation: *r-m* at or near midlength of $R_{4+5}$; cell $M_2$ open by atrophy of *m*.

Abdomen elongate; tergites and hypopygium dark brown; sternites obscure yellow, the outer segments darkened. Male hypopygium of the general type of *ampla* and *autumnalis;* basistyle with long coarse setae that exceed the dististyle in length. Dististyle (Fig. 32, *d*) with five unequal horns or spinous points, about as shown; a small fingerlike lobe with elongate setae.

*Holotype,* ♂, Leconte, Huffs Lodge, 6,400 ft., August 8, 1939 *(Mrs. J. Huff). Allotopotype,* ♀, pinned with type. *Paratopotypes* 10 ♀ ♂, July 30-September 7, 1939.

I am very pleased to name this distinct species in honor of Mrs. John Huff, whose collecting of crane-flies at and near the summit of Mount Leconte has added materially to our knowledge. The species is most nearly allied to *P. (T.) ampla* (Doane) of northwestern North America and *P. (T.) autumnalis* (Alexander) of northeastern North America. It differs conspicuously from both in the coloration, elongate antennae in the male, and open cell $M_2$ of the wings. The wings of the female are virtually equal in size to those of the male, not showing the marked reduction found in this sex in *autumnalis.*

*Pedicia (Tricyphona) auripennis* (Osten Sacken, 1859).—Silers trail, 6,300 ft., June 6; Leconte, Huffs Spring, 6,400 ft., June 13. This Canadian zone species had not been recorded from south of New York and Massachusetts.

*Pedicia (Tricyphona) inconstans* (Osten Sacken, 1859).—Leconte, Huffs Lodge, 6,400 ft., September 4 *(Mrs. J. Huff);* Gatlinburg, May 1, 1938 *(Williams);* Greenbrier, May 15-22, 1938, May 7, 1939 *(Williams);* Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman);* Cades Cove, May 8, 1938 *(Williams)* June 10.

**Pedicia (Tricyphona) inconstans calcaroides** subsp. nov.

Very similar to typical *inconstans* but with the wings virtually unpatterned and with the venational details distinct so that the fly superficially resembles the otherwise entirely distinct *calcar.*

Thorax almost uniformly orange yellow, without distinct stripes but often with a whitish bloom. Wings (Fig. 22) subhyaline or with a faint yellow tinge, the costal region and stigma more or less suffused with yellow or pale brownish yellow; no dark clouds at origin of *Rs* or along cord. Venation: *r-m* usually connecting with *Rs* a variable distance before the fork of latter, in cases this distance exceeding one-half the length of *r-m;* cell $R_3$ at origin erect to virtually perpendicular; cell $M_1$ short-petiolate to sessile. Male hypopygium as in the typical form.

*Holotype,* ♂, Anakeesta Ridge, 4,200 ft., June 5, 1939 *(C. P. Alexander); Allotopotype,* ♀, pinned with type. *Paratopotypes,* several ♀ ♂. *Paratypes,* Leconte, 5,800-6,400 ft., June 12-13, 1939; Silers trail, 6,000 ft., June 6; Andrews Bald bog, North Carolina, 5,800 ft., June 11, 1939 *(W. H. Harrison).*

The crane-fly above discussed is common and widely distributed at high altitudes throughout the Smokies. Superficially it resembles *calcar* but on the

basis of structure of the male hypopygium is unquestionably *inconstans*, from the typical form of which it is most readily told by the virtually unpatterned wings and slight venational details. One paratype, Alum Cove trail, Leconte. June 12, 1939, from the same spot discussed under *Limonia (Dicranomyia) uliginosa*, has the same unpatterned wings but with cell $R_3$ unusually long-

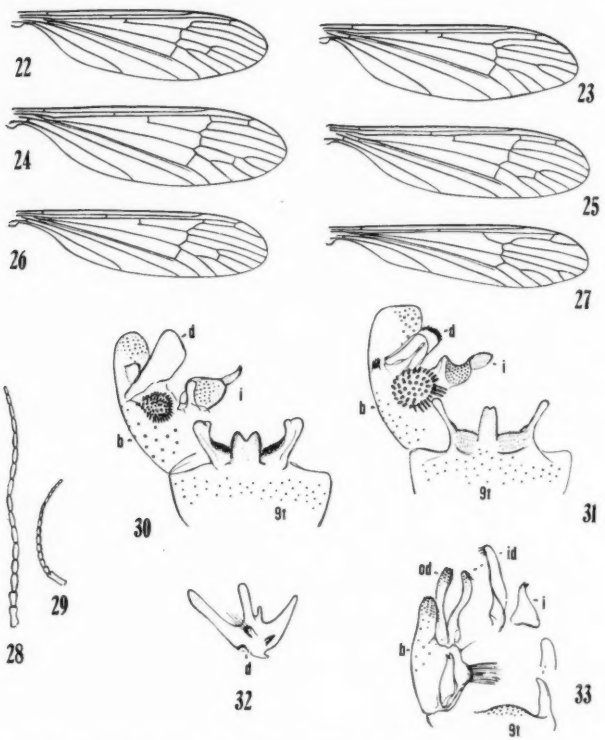


Fig. 22. *Pedicia (Tricyphona) inconstans calcaroides* subsp.n.; venation.
23. *Pedicia (Tricyphona) huffae* sp.n.; venation.
24–26. *Dicranota (Eudicranota) catawbiensis* sp.n.; venation, showing three extremes.
27. *Dicranota (Rhaphidolabis) hickmanae* sp.n.; venation.
28. *Pedicia (Tricyphona) huffae* sp.n.; antenna (♂).
29. *Pedicia (Tricyphona) autumnalis* (Alexander); antenna (♂).
30. *Dicranota (Eudicranota) catawbiensis* sp.n.; male hypopygium.
31. *Dicranota (Eudicranota) yonahlossee* Alexander; male hypogyium.
32. *Pedicia (Tricyphona) huffae* sp.n.; male hypopygium.
33. *Dicranota (Rhaphidolabis) hickmanae* sp.n.; male hypopygium.
(*Symbols: b*, basistyle; *d*, dististyle; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *t*, tergite.)

petiolate, with the origin of $R_{2+3}$ only slightly perpendicular. I am referring this specimen to this same clear-winged form which rather obviously requires a differentiating name.

**Pedicia (Tricyphona) vernalis catawba** subsp. nov.

♂. Length, about 7.5-9 mm.; wing, 8-10 mm.

♀. Length, about 11-13 mm.; wing, 11-12 mm.

Very similar to the typical *vernalis* (Osten Sacken, 1861) of northeastern North America, differing especially in the much more restricted wing pattern and in the details of structure of the male hypopygium. Wing markings much reduced, almost as in the otherwise distinct *paludicola* (Alexander). Male hypopygium with the setae before apex of dististyle abundant but delicate, evenly distributed over the extent of the style. Interbase with the feebly dilated head produced laterad into a short point.

*Holotype*, ♂, Indian Gap, Tennessee, 4,500 ft., June 17, 1939 *(C. P. Alexander)*. *Allotopotype*, ♀ with type. *Paratypes*, ♂ ♀, Leconte, Alum Cave trail, 5,000 ft., June 12, 1939; Leconte Lodge, 6,400 ft., July 31-August 25, 1939 *(Mrs. J. Huff)*; Chimneys Camp, 2,600 ft., June 11, 1939; Silers trail, 6,000 ft., June 6, 1939; Greenbrier, 2,000 ft., April 22 to May 7, 1939 *(Williams)*, Brushy Mt. trail, 2,500 ft., May 7, 1939 *(Cole)*, June 15, 1939 *(W. H. Harrison)*; Cades Cove, April 24, 1938 *(Williams)*. North Carolina: Black Mts., May 21 *(Nathan Banks)*; Cedar Mt., August 28, 1931 *(H. K. Townes)*; Andrews Bald bog, 5,860 ft., June 11, 1939 *(C. P. Alexander)*.

**Dicranota (Eudicranota) catawbiensis** sp. nov.

General coloration reddish yellow; antennal flagellum brownish black; halteres pale, the knobs weakly darkened; legs yellow, the tips of femora and tibiae blackened; wings subhyaline, the stigma not or scarcely differentiated; $R_{2+3+4}$ present; cell $M_1$ petiolate to broadly sessile; abdomen yellow, the ninth segment black; male hypopygium with the median tergal lobe broad, the apex with a wide U-shaped notch; interbasal lobe terminating in a flattened fascicle of bristles; dististyle appearing as a flattened horn-colored blade, the apex obtusely rounded and unarmed with spines or chitinized points.

♂. Length, about 5.5-6.5 mm.; wing, 6-7.5 mm.

♀. Length, about 7-7.5 mm.; wing, 7-7.8 mm.

Rostrum brown; palpi with basal segments brown, the outer segments paler. Antennae 14-segmented, short; scape and pedicel pale brown, flagellum brownish black, the more basal segments paler; flagellar segments oval, with very long verticils. Head brownish gray.

Thorax uniform reddish yellow, unmarked. Halteres pale, the knobs weakly darkened. Legs yellow, the tips of femora and tibiae and the outer tarsal segments blackened. Wings (Figs. 24-26) subhyaline, the stigma not or scarcely differentiated; prearcular field more yellowish; veins brown, conspicuous. Venation: $Sc_1$ ending about opposite the supernumerary crossvein in cell $R_1$;

*Rs* angulated to square at origin, usually conspicuously spurred; $R_{2+3+4}$ distinct, usually subequal in length to the supernumerary crossvein; cell $M_1$ usually petiolate, in cases sessile; *m-cu* beyond fork of *M*, the distance variable. As is usual in the Pediciine crane-flies, the venation in this species is variable, especially as regards the length of $R_{2+3+4}$ and the petiole of cell $M_1$. The figures given show three extremes of venation, the shortest $R_{2+3+4}$ being as in Fig. 25; in Fig. 24, cell $M_1$ is relatively long-petiolate, in Fig. 25 short-petiolate, while in Fig. 26 it is broadly sessile with *m* on $M_3$ about its own length beyond the fork. All such variations in venation occur rather commonly in the species.

Abdomen obscure yellow, the swollen ninth segment of the male black, the styli again yellow. Male hypopygium (Fig. 30) with the median tergal lobe, *9t*, relatively broad, with abundant setulae, at apex with a wide U-shaped notch; subtending arms of tergite relatively stout, with dense dark setae on inner margin at base. Interbasal lobe, *i*, terminating in a flattened fascicle of bristles. Basistyle, *b*, with outer lobe only moderately large and with a sparse armature of spiculae, the lower lobe with numerous coarse black spines. Dististyle, *d*, appearing as a flattened horn-colored blade, the apex obtusely rounded and without spines or chitinized points. The male hypopygium of the related *yonahlossee* is shown for comparison (Fig. 31); note especially the tergite, *9t*, and the armed dististyle, *d*.

*Holotype*, ♂, Alum Cave trail, Mount Leconte, 5,000 ft., June 12, 1939 *(C. P. Alexander)*. *Allotopotype*, ♀. *Paratopotypes*, several ♂ ♀, 4,500-6,000 ft., June 12-13, 1939, June 26-28, 1940; 1 ♂ at actual summit of Leconte, 6,590 ft., June 13, 1939; ♂ ♂, Silers trail, 6,200 ft., June 6, 1939; Forney Ridge, 5,800-6,300 ft., June 17, 1940, both in North Carolina and Tennessee.

*Dicranota (Eudicranota) catawbiensis* is readily told from its nearest ally, *D. (E.) yonahlossee* Alexander, of North Carolina, by the structure of the male hypopygium. Both species are entirely distinct from *D. (E.) pallida* Alexander, of the northeastern United States, and from *D. (E.) notabilis* Alexander, of the Cumberland Plateau, Tennessee. The present species and *Limnophila cherokeensis* sp. n., were the two most common crane-flies in mid-June at high altitudes on Mount Leconte. This fly was frequently noted while resting on low mossy cliffs along the trail.

*Dicranota (Amalopina) flaveola* (Osten Sacken, 1869).—Anakeesta Ridge, 3,300 ft., June 5; Leconte, Huffs Lodge, 6,400 ft., August 5-September 3, 1939 *(Mrs. J. Huff)*; Chimneys Camp, 2,700 ft., June 11; Greenbrier, May 15, 1938 *(Williams)*.

*Dicranota (Rhaphidolabis) persimilis* (Alexander, 1920). — Anakeesta Ridge, 4,000 ft., June 5; Leconte, Alum Cave trail, 4,000-5,000 ft., June 12; Greenbrier, Porters Creek, 2,500 ft., May 15, 1938, May 7 *(Williams)*.

**Dicranota (Rhaphidolabis) hickmanae** sp. nov.

General coloration gray, the praescutum with three brown stripes; antennae 13-segmented, black throughout; wings nearly hyaline, the stigma only faintly indicated; vein $R_{2+3+4}$ short; male hypopygium with the median area of tergite

darkened, moderately produced; lateral tergal arms appearing as flattened blades with obtuse apices; basistyle with a low lobe on mesal face, tipped with a dense brush of very long setae; interbase a flattened blade bearing two small teeth at apex; both dististyles narrow.

♂. Length, about 6 mm.; wing, 6-6.3 mm.

♀. Length, about 6.5 mm.; wing, 7 mm.

Rostrum gray; palpi black. Antenna black throughout, 13-segmented; flagellar segments oval, gradually decreasing in size outwardly. Head dark gray.

Mesonotal praescutum light gray, with three conspicuous brown stripes, the median one broader; scutal lobes extensively dark brown, median area of scutum and the posterior sclerites of notum gray. Pleura brownish gray. Halteres with stem pale, especially at base, knob darkened. Legs with coxae testaceous brown; trochanters pale; remainder of legs dark brown, the femoral bases somewhat paler. Wings (Fig. 27) nearly hyaline, the stigma only faintly indicated; veins dark brown. Venation: $R_{2+3+4}$ short, about two-thirds the basal section of $R_5$.

Abdomen, including hypopygium, dark brown. Male hypopygium (Fig. 33) with the median area of tergite, *9t*, moderately produced, darkened, with abundant setae; lateral tergal arms appearing as flattened blades with obtuse apices. Basistyle, *b*, with outer lobe conspicuous, about one-half the length of the more slender outer dististyle but with similar spinous armature; mesal face of basistyle with a low lobe that bears at apex a dense brush of very long setae. Interbase, *i* ,a flattened blade terminating in two small teeth. Outer dististyle, *od*, clavate, with spinous setae on distal half. Inner dististyle unusually long and slender, subequal to or a little longer than the outer style, at apex with a few erect spinous setae.

*Holotype*, ♂, Mt. Leconte, near Huffs Lodge, 6,400 ft., September 2, 1939 *(Mrs. J. Huff)*. *Allotopotype*, ♀, pinned with type. *Paratopotypes*, ♂ ♀, August 25-September 7, 1939 *(Mrs. J. Huff)*. What seems to be this same species but represented only by females was taken by Dr. Cole and Miss Hickman along Brushy Mountain trail, 3,500 ft., September 16, 1939.

*Dicranota (Rhaphidolabis) hickmanae* is named in honor of Mrs. Arthur C. Cole (Miss Mary E. Hickman) who collected many of the new and rare species of crane-flies discussed in this report. The fly is quite distinct from all of the now somewhat numerous species of the subgenus in eastern North America. In the lobe on the mesal face of the basistyle of the male hypopygium it agrees with *D. (R.) forceps* Alexander and *D. (R.) persimilis* (Alexander) but the nature of this lobe and its vestiture is quite different from that of any of our species. The low median lobe of the tergite, structure of the interbase, and elongate dististyles, similarly separate the species from all allied forms.

*Dicranota (Rhaphidolabis) rubescens* (Alexander, 1916). — Anakeesta Ridge, 3,500-4,000 ft., June 5; Leconte, Alum Cave trail, 4,600 ft., June 12.

*Dicranota (Plectromyia) confusa* (Alexander, 1924).—Silers trail, 5,800-6,000 ft., June 6; Clingmans Dome, 6,400 ft., June 6, and 18, along small stream in a dense growth of fir; Indian Gap, 4,700 ft., June 9; Leconte, Alum

Cave trail, 5,800-6,000 ft., June 12; Huffs Lodge, 6,400 ft., June 13. Restricted to the spruce-fir zone.

HEXATOMINI

*Oxydiscus (Oxydiscus) americanus* (Alexander, 1912).—Leconte, Huffs Lodge, 6,400 ft., August 22-September 7, 1939 *(Mrs. J. Huff)*.

*Oxydiscus (Oxydiscus) minutus* (Alexander, 1911).—Silers trail, in wet swale, 5,800 ft., June 6; Anakeesta Ridge, 4,000-4,700 ft., June 5; Leconte, Alum Cave trail, 4,000-4,500 ft., June 12; Huffs Lodge, 6,400 ft., June 12-13.

*Oxydiscus (Oxydiscus) pleuralis* (Dietz, 1921).—Indian Gap, 4,800 ft., June 17 *(Cole & Hickman)*; Greenbrier, Brushy Mt. trail, 2,000-2,500 ft., June 15.

*Epiphragma (Epiphragma) fascipennis* (Say, 1823).—Indian Gap, 5,300-5,500 ft., June 5; Anakeesta Ridge, 3,500-4,500 ft., June 5-7; Leconte, Huffs Lodge, 6,400 ft., June 12-13; Greenbrier, Brushy Mt. trail, 2,500 ft., May 20 *(Williams)*.

*Epiphragma (Epiphragma) solatrix* (Osten Sacken, 1859).—Greenbrier, May 15-22, 1938 *(Williams)*; 2,500 ft., May 7 *(Williams)*; 2,300 ft., June 15 *(W. H. Harrison)*.

*Prolimnophila areolata* (Osten Sacken, 1859).—Silers trail, 5,800-6,000 ft., June 6; Indian Gap, 5,300-5,500 ft., June 9; Anakeesta Ridge, 4,000-4,700 ft., June 5; Leconte, Alum Cave trail, 4,000-6,000 ft., June 12, summit, 6,590 ft., June 13; Greenbrier, 2,500 ft., May 7 *(Williams)*; Brushy Mt. trail, 3,000-4,500 ft., June 15.

*Pseudolimnophila contempta* (Osten Sacken, 1869).—Greenbrier, 1,800 ft., June 7; 2,200-2,500 ft., June 15; May 15, 1938 *(Williams)*; Brushy Mt. trail, 3,500 ft., September 16, 1939 *(Cole & Hickman)*.

*Austrolimnophila toxoneura* (Osten Sacken, 1859).—Silers trail, 6,000-6,300 ft., June 6; Indian Gap, 5,000-5,300 ft., June 9, 4,800 ft., June 17 *(Cole & Hickman)*; Leconte, Alum Cave trail, 4,000-5,500 ft., June 12; Greenbrier, May 15, 1938 *(Williams)*, Brushy Mt. trail, 3,500-4,500 ft., June 15; Cades Cove, Myers Lodge, June 10 *(M. M. Alexander)*. One of the commonest crane-flies in the Canadian zone, somewhat less numerous in the Transition.

*Dactylolabis cubitalis* (Osten Sacken, 1869).—Chimneys Camp, 2,700 ft., April 30, 1939 *(Williams)*.

*Dactylolabis montana* (Osten Sacken, 1859).—Newfound Gap and Anakeesta Ridge, 4,000-5,000 ft., June 5 and 7; Leconte, Alum Cave trail, 5,000-6,000 ft., June 12; Greenbrier, May 15, 1938, May 7, 1939 *(Williams)*. Common and conspicuous on dripping faces of cliffs, sometimes associated with the next.

*Dactylolabis hudsonica* Alexander, 1931.—Silers trail, 6,000 ft., June 6; Newfound Gap, 5,000 ft., June 5; Leconte, Alum Cave trail, 4,500-6,000 ft., June 12; Huffs Lodge, 6,400 ft., June 12-13; Greenbrier, May 7, 1939 *(Williams)*; Cades Cove, April 24, 1938 *(Williams)*. Although often found on wet cliffs, the present species occasionally occur on tree trunks. This was

noted especially along the Silers trail, where the trunks of Frasers Fir are densely moss covered; here occurred many *Limonia indigena* and *Epiphragma fascipennis*, with occasional specimens of the present fly. I had never before seen the spotted-winged species of the genus in such a habitat although the unpatterned species, as *D. cubitalis*, are less lithophilous in their habits.

*Limnophila (Lasiomastix) macrocera* (Say, 1823).—Indian Gap, 4,800 ft., June 17 *(Cole & Hickman)*; Greenbrier, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*; Gregory Ridge trail, spring at the Gantlot, in swale, 4,800 ft., June 17.

*Limnophila (Lasiomastix) tenuicornis* Osten Sacken, 1869.—Leconte, Alum Cave trail, 4,400 ft., among the dense "hobbles" of *Rhododendron maximum* L. and *Leucothoë Catesbaei* (Walt.) Gray, associated with *Limnophila (Prionolabis) munda*, June 12 *(M. M. Alexander)*; Greenbrier, 2,500 ft., May 15, 1938, May 20, 1939 *(Williams)*.

*Limnophila (Elaeophila) aprilina* Osten Sacken, 1859.—Greenbrier, 2,500 ft., May 7, 1939 *(Williams)*.

*Limnophila (Elaeophila) solstitialis* Alexander, 1926.—Greenbrier, 1,700 ft., June 7, along small accessory stream underneath hemlock.

*Limnophila (Trichephelia) seticellula* Alexander, 1938.—Greenbrier, Brushy Mt. trail, 2,300 ft., June 15.

*Limnophila (Dicranophragma) angustula* Alexander, 1929. — Anakeesta Ridge, 3,300 ft., June 5; Chimneys Camp, 2,700 ft., June 7; Little River Gorge, 1,300-1,400 ft., on wet cliffs, June 10; Gregory Ridge trail, Gantlot, 4,800 ft., June 17.

*Limnophila (Dicranophragma) fuscovaria* Osten Sacken, 1859.—Greenbrier, May 15, 1938 *(Williams)*, 1,800-1,900 ft., June 7; Cades Cove, May 8, 1938 *(Williams)*.

*Limnophila (Prionolabis) rufibasis* Osten Sacken, 1859.—Anakeesta Ridge, 5,000 ft., June 5; Silers trail, 6,000 ft., June 6; Leconte, summit, 6,590 ft., June 12. Common at high altitudes; praescutal stripes opaque.

*Limnophila (Prionolabis) walleyi* Alexander, 1929.—Newfound Gap and Anakeesta Ridge, 4,500-5,000 ft., June 5-7; Newfound Gap to Indian Gap, 4,800 ft., June 9; Leconte, Alum Cave trail, 4,600-5,800 ft., June 12; Greenbrier, May 7 *(Cole)*, May 20 *(Williams)*. There is still confusion in this section of the subgenus. What appears to represent this single species has the praescutal stripes opaque or, in cases, highly polished.

*Limnophila (Prionolabis) munda* Osten Sacken, 1869.—Leconte, Alum Cave trail, 4,400 ft., June 12 *(M. M. Alexander)*, from dense "hobbles" or thickets of *Rhododendron maximum* and *Leucothoë Catesbaei*; near summit of Leconte, 6,000 ft., June 12; Leconte Creek trail, 5,500 ft., June 13; Cades Cove, Gregory Ridge trail, 2,500 ft., June 17.

**Limnophila (Phylidorea) stupkai** sp. nov.

Allied to *lutea*; general coloration brown, sparsely dusted with yellow; femora obscure yellow, the tips infuscated; wings yellow, unmarked except for

the small pale brown stigma; abdominal tergites dark brown with a black subterminal ring; male hypopygium with the phallosome appearing as three blackened spines, the central one from a bulbous base set with acute spinous points arising from tesselated plates or areas; flange of aedeagus relatively narrow, without spinulae.

♂. Length, about 7-7.5 mm.; wing, 8-9 mm.

Rostrum dark brown; palpi brownish yellow. Antennae with scape and pedicel dark brown, flagellum obscure brownish yellow, the outer segments darker; flagellar segments oval, with long conspicuous verticils; terminal segment about one-half longer than the penultimate. Head yellowish gray, more yellow pollinose on the front and orbits.

Mesonotum brown, sparsely dusted with yellow. Pleura yellowish brown, sparsely pruinose. Halteres with stem yellow, knob dark brown. Legs with the coxae reddish yellow; trochanters yellow; femora obscure yellow, the tips infuscated; tibiae obscure yellow, the tips more narrowly dark brown; tarsi yellowish brown, the outer segments black. Wings (Fig. 34) yellow, the prearcular and costal fields clearer yellow; stigma small, oval, pale brown, inconspicuous against the ground; veins brown, more yellowish in the clearer ground areas. Venation: *Rs* moderately long, strongly arcuated to angulated and short-spurred at origin; *m-cu* at or beyond midlength of cell *1st* $M_3$.

Abdominal tergites dark brown, the sternites more yellowish brown; subterminal segments blackened; hypopygium pale yellow. Male hypopygium (Fig. 36) with the dististyles pale, the outer style, *od*, narrowly blackened and weakly bidentate at apex. Phallosome, *p*, appearing as three spinous apophyses, the central one from an oval blackened base that is provided with several acute spinous points arising from reticulated or tesselated areas or plates. Aedeagus, *a*, sinuous at base, of moderate width only, without spinulae as in *lutea*.

*Holotype*, ♂, Mount Leconte, Alum Cave trail, 6,000 ft., June 13, 1939 *(C. P. Alexander)*. *Paratypes*, 1 ♂, Clingmans Dome, 6,000 ft., June 11, 1939; 1 ♂, Leconte trail, 5,000 ft., June 13, 1939; 1 ♂, Andrews Bald bog, North Carolina, 5,860 ft., June 11 1939; Forney Ridge, 5,000-6,200 ft., June 17-18, 1940 *(C. P. Alexander)*.

I take great pleasure in naming this interesting new species in honor of the capable Park Naturalist, Mr. Arthur Stupka, to whom we are greatly indebted for many favors. *Limnophila (Phylidorea) stupkai* is most similar to *L. (P.) lutea* Doane, of northeastern North America, differing especially in the coloration of the body and in the structure of the male hypopygium, notably of the aedeagus and gonapophyses.

*Limnophila (Phylidorea) subcostata* Alexander, 1911.—Silers trail, swale near Double Spring Gap, 5,800 ft., June 6; Anakeesta Ridge, from beds of *Diphylleia*, 4,500 ft., June 8; Leconte, Huffs Lodge, bog, 6,400 ft., June 12-13.

*Limnophila brevifurca* Osten Sacken, 1859.—Anakeesta Ridge, 4,500-5,000 ft., June 5; Greenbrier, Brushy Mt. trail, 2,500 ft., May 20, 1939 *(Williams)*.

*Limnophila albipes* Leonard, 1913. — Greenbrier, along small accessory

stream at Forks of Porters Creek and the Middle Prong of Little Pigeon River, 1,700-1,750 ft., June 7.

**Limnophila cherokeensis** sp. nov.

Allied to *niveitarsis;* general coloration black, pruinose with gray; antennae of male elongate; posterior tarsi white; wings with a strong brownish tinge; $R_{2+3+4}$ unusually long, from two-thirds to fully as long as *Rs* and approximately twice *m-cu;* male hypopygium with the outer dististyle uniformly darkened, unequally bidentate at apex; basistyle and inner dististyle without modified groups of spinous setae; one pair of gonapophyses on either side of the trifid aedeagus.

♂. Length, about 5.5-6.5 mm.; wing, 6.5-7.5 mm.; antenna, about 2.8-3 mm.

♀. Length, about 6.5-7 mm.; wing, 7-7.5 mm.

Rostrum and palpi black. Antennae black, the base of first flagellar segment brightened; antennae of male elongate, approximately one-half the length of body; flagellar segments elongate-oval to fusiform. Head gray.

Thorax black, heavily to very sparsely dusted with gray, the color thus appearing opaque dark gray to subnitidous black, dorsopleural membrane dark. Halteres with stem pale, knob weakly darkened. Legs with coxae yellow, the fore pair a little darker; trochanters yellow; femora obscure yellow, the tips blackened, only a little more extensive on fore pair where about the distal fourth is darkened; tibiae dark brown, the tips narrowly black; fore and middle tarsi light brown; posterior tarsi snowy white, the outer segment darkened;

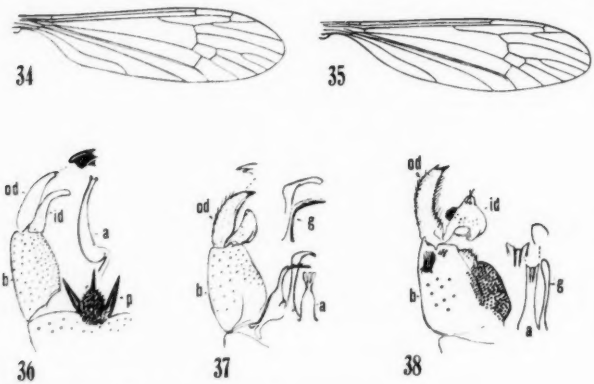


Fig. 34. *Limnophila (Phylidorea) stupkai* sp.n.; venation.
35. *Limnophila cherokeensis* sp.n.; venation.
36. *Limnophila (Phylidorea) stupkai* sp.n.; male hypopygium.
37. *Limnophila cherokeensis* sp.n.; male hypopygium.
38. *Limnophila globulifera* Alexander; male hypopygium.
(*Symbols: a,* aedeagus; *b,* basistyle; *g,* gonapophysis; *id,* inner dististyle; *od,* outer dististyle; *p,* phallosome.)

posterior basitarsi not dilated on proximal portion nor with modified setae. Wings (Fig. 35) with a strong brown tinge, the perarcular field more yellow; stigma oval, very faintly darker than the ground; veins dark brown. Venation: $Sc_1$ ending opposite or shortly before fork of *Rs*, $Sc_2$ near its tip; $R_{2+3+4}$ unusually long, from about two-thirds to fully equal in length to *Rs* and at least twice the length of *m-cu;* cell *1st* $M_2$ varying from rectangular to short-rectangular, with *m-cu* at or beyond midlength.

Abdomen with tergites black, the sternites pale brown to obscure brownish yellow medially, blackened on sides; hypopygium black. Male hypopygium (Fig. 37) with the basistyle, *b*, simple, without modified groups of spines or blackened setae; mesal face of basistyle with small groups or stellate areas of microscopic setulae. Outer dististyle, *od*, entirely blackened, unequally bidentate at apex. Inner dististyle small and simple, without modified spinous setae. Gonapophyses, *g*, appearing as two distinct pairs, the outer ones expanded beyond midlength into boomerang-shaped blades; inner apophyses appearing as slender curved chitinized rods; under higher magnification, the distal third with hyaline outer membrane set with microscopic spinules. Aedeagus, *a*, trifid at apex, as in the *niveitarsis* group. I have shown the male hypopygium of the related *globulifera* for comparison (Fig. 38).

*Holotype*, ♂, Silers trail, 6,000 ft., June 6, 1939 *(C. P. Alexander). Allotopotype*, ♀. *Paratopotypes*, numerous ♂ ♀; *paratypes*, numerous ♂ ♀ from various stations in the Great Smokies, 4,400-6,400 ft., June 6-18, 1939 and June 17-28, 1940, including Silers trail, on both the North Carolina and Tennessee sides; Clingmans Dome and Forney Ridge, on North Carolina side; Indian Gap; Mt. Leconte, on both Alum Cave and Leconte Creek trails.

*Limnophila cherokeensis* is amply distinct from the other members of the *niveitarsis* group, including *L. globulifera* Alexander and *L. niveitarsis* Osten Sacken It is most readily told by the unusually long $R_{2+3+4}$ which is fully twice as long as *m-cu*, and especially by the very distinct male hypopygium, as described above. This fly was one of the most common and characteristic flies of the spruce-fir forests at high altitudes in the Great Smokies, being unusually numerous near Clingman's Dome and Forney Ridge, and on Mount Leconte. *L. niveitarsis* has been recorded both from Tennessee (Cumberland Plateau) and North Carolina (Wake Co.) but I have not seen it from so far south and it is possible that these records pertain to one or another species of the same group subsequently described.

*Shannonomyia lenta* (Osten Sacken, 1859).—Indian Gap, 5,300 ft., June 9; 4,800 ft., June 17 *(Cole & Hickman);* Chimneys Camp, 2,700 ft., July 26 *(Cole);* Greenbrier, Brushy Mt. trail, 3,500-4,000 ft., June 15 *(Cole, Harrison and Hickman).*

*Ulomorpha pilosella* (Osten Sacken, 1859). — Anakeesta Ridge, 4,000-4,700 ft., June 5; Chimneys Camp, 2,700 ft., June 7; Leconte, Huffs Lodge, 6,400 ft., August 1-5 *(Mrs. J. Huff);* Greenbrier, May 15-22, 1938 *(Williams);* Brushy Mt. trail, 2,000-4,000 ft., June 15; 3,500 ft., September 16 *(Cole & Hickman);* Cades Cove, Myers Lodge, 1,900 ft., June 10.

*Atarba (Atarba) picticornis* Osten Sacken, 1869.—Foot of trail to the

Chimneys, 3,200 ft., June 18 *(W. H. Harrison);* Greenbrier, Brushy Mt. trail, 2,000-3,500 ft., June 15, abundant, many mating *(Cole, Harrison and Hickman);* Cades Cove, Gregory Ridge trail, 2,800 ft., June 17.

*Elephantomyia (Elephantomyia) westwoodi* Osten Sacken, 1869.—Indian Gap, 5,200 ft., June 10 *(Cole & Hickman);* foot of Chimneys trail, 3,200 ft., June 18 *(Harrison);* Chimneys Camp, 2,700 ft., July 2 *(Cole);* Leconte, Alum Cave trail, 4,200-4,800 ft., June 12; Greenbrier, Brushy Mt. trail, 4,000-4,500 ft., June 15.

*Hexatoma (Eriocera) cinerea* (Alexander, 1912).—Greenbrier, May 15, 1938 *(Williams);* Cades Cove, along Forge Creek, 1,900 ft., June 10.

*Hexatoma (Eriocera) fuliginosa* (Osten Sacken, 1859).—Greenbrier, near Forks, 1,800 ft., June 7; Cades Cove, Myers Lodge, 2,000 ft., June 17 *(M. M. Alexander).* These specimens vary considerably in size and in intensity of coloration, the male from Cades being considerably larger and darker in color. The intermediate praescutal stripes are confluent or virtually so, except at their posterior ends.

*Hexatoma (Eriocera) albitarsis* (Osten Sacken, 1869).—Chimneys Camp, 2,700 ft., July 13 *(Cole);* Greenbrier, 2,000 ft., June 15, Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman);* Cades Cove, Rich Mt., 1,950 ft., June 10 *(M. M. Alexander),* Myers Lodge, 2,000 ft., June 17 *(M. M. Alexander).*

ERIOPTERINI

*Neolimnophila ultima* (Osten Sacken, 1859), var. Clingmans Dome, 6,000 ft., June 11 *(W. H. Harrison);* Leconte, Rainbow trail, 2,000-3,500 ft., June 13. The identity seems assured but only females have been discovered and the male sex may show unsuspected differences.

*Cladura (Cladura) flavoferruginea* Osten Sacken, 1859.—Chimneys Camp, 2,700 ft., October 21 *(Cole & Hickman).*

*Gonomyia (Lipophleps) manca* (Osten Sacken, 1869). — Greenbrier, Porters Creek, 2,000 ft., June 15 *(M. E. Hickman).*

*Gonomyia (Lipophleps) sulphurella* Osten Sacken, 1859. — Chimneys Camp, along small stream, 2,600 ft., June 11.

*Gonomyia (Gonomyia) subcinerea* Osten Sacken, 1859.—Greenbrier, May 15, 1938 *(Williams),* Brushy Mt. trail, 2,500 ft., May 20 *(Williams);* Cades Cove, Myers Lodge, 1,900 ft., June 10.

*Gnophomyia tristissima* Osten Sacken, 1859.—Greenbrier, May 22, 1938 *(Williams),* 2,500 ft., May 7 *(Williams);* Brushy Mt. trail, 2,400-3,000 ft., June 15; 3,500 ft., September 16 *(Cole & Hickman).*

*Teucholabis (Teucholabis) immaculata* Alexander, 1922.—Cades Cove, Rich Mt., 1,950 ft., June 10 *(M. M. Alexander).*

This species was originally characterized as a subspecies of *T. (T.) complexa* Osten Sacken, 1859, and was based upon the immaculate nature of the mesonotum of the types. It is now evident that there are two very distinct

species confused under the name *complexa,* these being very similar in general appearance but differing notably in the structure of the male hypopygium.

The original description of *complexa* indicates that both species were confused by Osten Sacken but his figure of the male hypopygium (Mon. Dipt. N. Amer., 4, pl. 3, figs. 9, 9a; 1869), while very diagrammatic, can pertain only to one of these species. Accordingly I am herewith designating as lectotype of the species, the specimen in the original series (Museum of Compara-

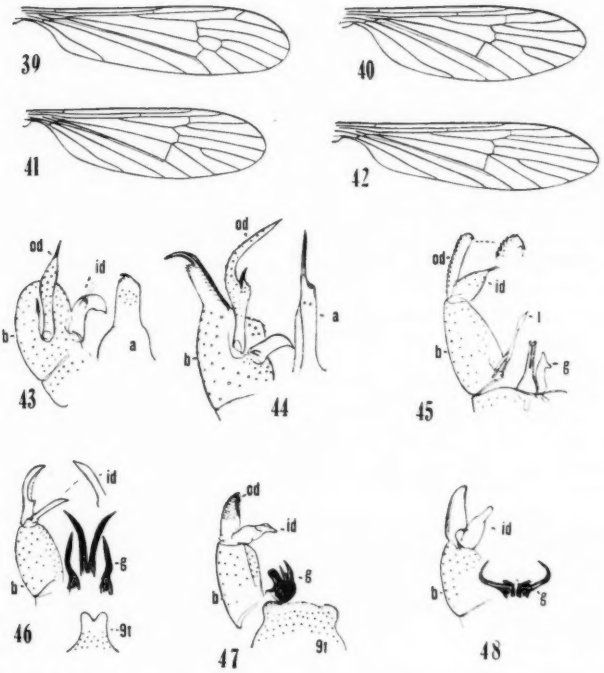


Fig. 39. *Rhabdomastix margarita* sp.n.; venation.
40. *Ormosia (Ormosia) tennesseensis* sp.n.; venation.
41. *Ormosia (Ormosia) harrisoniana* sp.n.; venation.
42. *Ormosia (Ormosia) lilliana* sp.n.; venation.
43. *Teucholabis (Teucholabis) complexa* Osten Sacken; male hypopygium.
44. *Teucholabis (Teucholabis) immaculata* Alexander; male hypopygium.
45. *Rhabdomastix margarita* sp.n.; male hypopygium.
46. *Ormosia (Ormosia) tennesseensis* sp.n.; male hypopygium.
47. *Ormosia (Ormosia) harrisoniana* sp.n.; male hypopygium.
48. *Ormosia (Ormosia) lilliana* sp.n.; male hypopygium.
(*Symbols: a,* aedeagus; *b,* basistyle; *g,* gonapophysis; *i,* interbase; *id,* inner dististyle; *od,* outer dististyle; *t,* tergite.)

tive Zoölogy, Cambridge, Mass.) upon which this figure is based, with the hypopygium conforming to the description given herewith. The two species may be differentiated as follows:

*Teucholabis (Teucholabis) complexa* Osten Sacken. Male hypopygium (Fig. 43) with the tip of basistyle, *b*, obtusely rounded, the spine lateral in position and very small. Outer dististyle, *od*, a simple straight rod that terminates in an acute apical spine. Inner dististyle with the outer blade nearly simple, the basal lobe with two long setae, as shown by Osten Sacken. Aedeagus, *a*, obtuse at apex, the terminal spine very short, curved and reduced, scarcely visible except under high magnification.

*Teucholabis (Teucholabis) immaculata* Alexander. Male hypopygium (Fig. 44) with the spine of basistyle, *b*, apical, from a conspicuous expanded basal blade. Outer dististyle, *od*, a long sinuous rod, the tip an acute spine, at near midlength bearing a strong lateral thorn. Inner dististyle small. Aedeagus, *a*, terminating in a long straight apical spine that is more than a third as long as the entire aedeagus.

Unfortunately, the immaculate mesonotum of the types of *immaculata* is not constant for the species since many, if not most, of the known specimens have three unusually heavy black praescutal stripes and the thoracic pleura heavily patterned with black.

*Lipsothrix sylvia* (Alexander, 1916).—Silers trail, 5,800 ft., June 6; Anakeesta Ridge, 4,500-4,700 ft., June 5-8; Leconte, Alum Cave trail, 4,500-5,500 ft., June 12; Greenbrier, 2,500 ft., April 22, May 20, 1939 *(Williams);* Cades Cove, April 24, 1938 *(Williams);* Myers Lodge, 1,900 ft., June 10.

The beds of bears-foot or umbrella leaf, *Diphylleia cymosa* Michx., at Anakeesta Ridge harbor a number of species of Tipulidae. On June 8, the following species were collected from such a bed: *Tipula (Yamatotipula) cayuga* Alexander, *Tipula (Schummelia) hermannia* Alexander, *Dolichopeza (Oropeza) subvenosa* sp. n., *Liogma nodicornis flaveola* Alexander, *Limonia (Dicranomyia) humidicola* (Osten Sacken), *Prolimnophila areolata* (Osten Sacken), *Austrolimnophila toxoneura* (Osten Sacken), *Limnophila (Phylidorea) subcostata* (Alexander), *Limnophila cherokeensis* sp. n., and the present species.

*Erioptera (Erioptera) megophthalma* Alexander, 1918.— Greenbrier, May 15, 1938 *(Williams).*

*Erioptera (Erioptera) septemtrionalis* Osten Sacken, 1859.—Silers trail, 6,000-6,200 ft., June 6, common along trail; Leconte, Huffs Lodge, 6,400 ft., June 13; July 26 *(Mrs. J. Huff);* Chimneys Camp, 2,700 ft., June 8; Greenbrier, 2,000 ft., November 12, 1938 *(Williams).*

*Erioptera (Erioptera) vespertina* Osten Sacken, 1869.—Park, near Gatlinburg, May 1, 1938 *(Williams).*

*Erioptera (Hoplolabis) armata* Osten Sacken, 1859.—Greenbrier, 2,000 ft., May 7, 1939 *(Williams).*

*Erioptera (Symplecta) cana* (Walker, 1848) (*hybrida* Meigen, 1804).—Park, near Gatlinburg, May 1, 1938 *(Williams).*

*Erioptera (Mesocyphona) needhami* Alexander, 1918.—Greenbrier, near Forks, 1,800 ft., June 7.

*Erioptera (Empeda) stigmatica* (Osten Sacken, 1869).—Silers trail, 6,200 ft., June 6; Indian Gap, 4,800 ft., June 17 *(Cole & Hickman);* Leconte, Rainbow Falls, 2,500 ft., June 13; Greenbrier, 2,000 ft., May 7, 1939 *(Williams).*

*Erioptera (Gonempeda) nyctops* Alexander, 1916.—Indian Gap, 5,300 ft., June 9; Leconte, Alum Cave trail, 5,500-6,000 ft., June 12; Huffs Lodge, bog, 6,400 ft., June 13; Leconte Creek trail, 6,000-6,200 ft., June 13.

*Rhabdomastix hansoni* Alexander.—Greenbrier, Forks, 1,800 ft., June 7; Cades Cove, Gregory Ridge trail, 2,600 ft., among dense growth of *Rhododendron maximum,* June 17.

**Rhabdomastix margarita** sp. nov.

General coloration reddish brown; antennae (male) elongate, only a little shorter than the entire body; wings with a weak brown tinge, the oval stigma vaguely darker; veins conspicuous, brown, the macrotrichia long; $Sc_1$ ending about opposite midlength of *Rs*, $Sc_2$ present or lost by atrophy; *m-cu* shortly before midlength of cell *1st* $M_2$; abdomen yellowish brown, the terminal two segments brownish black; male hypopygium with the interbases slender, the apex expanded into a weak triangular head.

♂. Length, about 5.5-6 mm.; wing, 6.3-7 mm.; antenna, about 4.7-5 mm.

♀. Length, about 5.5 mm.; wing, 5 mm.

Rostrum and palpi dark brown. Antennae with scape and pedicel obscure yellow, flagellum black; antennae (male) elongate, only a little shorter than the body; flagellar segments cylindrical with a long erect white pubescence and short, subequal verticils that are much shorter than the segments. Antennae of female much shorter but still long for this sex in the genus. Head brownish gray; anterior vertex wide.

Pronotum obscure yellow. Mesonotum reddish brown, the surface subnitidous, in cases with the anterior portion of praescutum darker medially. Pleura reddish yellow, unmarked. Halteres dusky, the base of stem pale. Legs with coxae and trochanters yellow; femora obscure brownish yellow, the tips darkened; tibiae obscure yellow, the tips narrowly darkened; tarsi chiefly yellow, the outer segments darkened. Wings (Fig. 39) with a weak brown tinge, the oval stigma vaguely darker; prearcular field more yellow; veins brown, conspicuous. Macrotrichia of veins beyond cord long and conspicuous, well distributed on all veins excepting *Rs*. Venation: $Sc_1$ ending about opposite midlength of *Rs*, $Sc_2$ in cases present, in still other specimens atrophied; $R_3$ oblique, separated from $R_{1+2}$ on costa by a distance a little greater than its length; *m-cu* shortly before midlength of cell *1st* $M_2$, the latter variable in size, in the holotype unusually small; veins issuing from cell *1st* $M_2$ moderately arcuated; cell *2nd A* relatively narrow.

Abdomen yellowish brown, the basal tergites somewhat darker; eighth and ninth segments brownish black; hypopygium yellowish brown. Male hypo-

pygium yellowish brown. Male hypopygium (Fig. 45) with the basistyle, *b*, elongate; interbase, *i*, with the stem slender, the apex expanded into a weak triangular head. Outer dististyle, *od*, with appressed spinules along outer face; apex a simple decurved spine. Inner dististyle, *id*, stout, narrowed to a small point.

*Holotype*, ♂, Mount Leconte, Leconte Creek trail, near Rainbow Falls, 2,500 ft., June 13, 1939 *(C. P. Alexander)*. *Allotype*, ♀, Leconte Lodge, near summit of Mount Leconte, 6,400 ft., July 31, 1939 *(Mrs. J. Huff)*. *Paratypes*, 1 ♂, with allotype, July 30, 1939 *(Mrs. J. Huff)*; 3 ♂♂, Linville Falls, Burke Co., North Carolina, 3,200 ft., June 21, 1939 *(M. M. Alexander)*.

*Rhabdomastix margarita* is affectionately dedicated to Mrs. Alexander who collected part of the type material, as well as many of the other specimens recorded in this paper. The elongate antennae of the male sex readily separates the fly from all other species in the Nearctic fauna. The length and nature of the antennae is about intermediate between the elongate condition in typical *Rhabdomastix* Skuse and the short type found in *Sacandaga* Alexander. If a name were deemed advisable for such species, the subgeneric term *Palaeogonomyia* Meunier, 1899, 1906, based on certain fossil species (Oligocene: Baltic Amber) is available. However, since the character of length of antennae is a sexual one, it seems preferable to drop these various subgeneric groups except to designate groups of species within the now complex genus *Rhabdomastix*. Professor Rogers informed me that he had taken this same species in the southern Appalachians but unfortunately his material was not available to me for inclusion in the type series of the species.

*Ormosia (Ormosia) apicalis* Alexander, 1911.— Greenbrier, May 20, 1939 *(Williams)*; Cades Cove, Rich Mt., 1,950 ft., June 10.

*Ormosia (Ormosia) innocens* (Osten Sacken, 1869).—Silers trail, in swale near Double Spring Gap, 5,800 ft., June 6.

*Ormosia (Ormosia) nubila* (Osten Sacken, 1859).—Park, near Gatlinburg, October 23, 1938 *(Williams)*; Greenbrier, 2,000 ft., April 22, 1939 *(Williams)*; Brushy Mt. trail, 3,500 ft., September 16 *(Cole & Hickman)*; Cades Cove, April 24, 1938 *(Williams)*, Rich Mt., 1,950 ft., April 15 *(Cole)*.

*Ormosia (Ormosia) arcuata* (Doane, 1908).—Greenbrier, Brushy Mt. trail, May 20, 1939 *(Williams)*. Although only females are available, there seems to be no possible doubt of the identity.

*Ormosia (Ormosia) nigripila* (Osten Sacken, 1869).—Anakeesta Ridge, 4,700 ft., June 9, near upper tunnel; Greenbrier, Brushy Mt. trail, 2,000 ft., May 7-20, 1939 *(Williams)*; 3,500 ft., September 16 *(Cole & Hickman)*.

*Ormosia (Ormosia) holotricha* (Osten Sacken, 1959).—Silers trail, 6,000-6,200 ft., June 6.

**Ormosia (Ormosia) tennesseensis** sp. nov.

Allied to *meigenii*; male hypopygium with the inner dististyle a simple narrow cultriform blade; gonapophyses simple, without lateral teeth or spines.

♂. Length, about 4.6-5 mm.; wing, 5.2-6 mm.

Rostrum brown; palpi black. Antennae short,black; flagellar segments long-oval, with very long verticils. Head brownish gray.

Pronotum brown; pretergites yellow. Mesonotum brownish gray, without distinct stripes. Pleura brownish gray. Halteres yellow, the knobs clearer yellow. Legs with coxae brownish yellow; trochanters obscure yellow; femora obscure brownish yellow, the tips weakly darkened; tibiae and tarsi dark brown. Wings (Fig. 40) subhyaline, patterned with brown, including a conspicuous stigmal area; cells *C* and *Sc* darkened; restricted dark seams along cord and certain of the longitudinal veins; more whitish areas before and beyond stigma; base and outer end of cell *R*, cell $M_3$ and bases of Anal cells whitened; veins brown. Venation: $R_2$ at or just beyond fork of $R_{2+3+4}$; *m-cu* before fork of *M*, in cases up to one-third its own length; Anal veins convergent.

Abdomen dark brown, male hypopygium a trifle brightened. Male hypopygium (Fig. 46) with the median tergal lobe, *9t*, relatively narrow. Outer dististyle, *od*, a simple curved rod, the concave inner face with pale membrane. Inner dististyle, *id*, a simple narrow cultriform blade. Gonapophyses, *g*, simple, all without lateral teeth or spines, the central pair about one-third longer than the more slender lateral apophyses.

*Holotype*, ♂, Greenbrier Cove, 2,000 ft., March 12, 1939 *(Williams)*. *Paratopotypes*, 3 ♂♂, pinned with type; *paratypes*, 2 ♂♂ on one pin, Knoxville, March 4, 1938; 4 ♂♂ on one pin, Love Brook, Knoxville, March 12, 1938 *(Williams)*.

*Ormosia (Ormosia) tennesseensis* is very similar in its general appearance to *O. (O.) meigenii* (Osten Sacken) but is quite distinct in the structure of the male hypopygium, especially of the inner dististyle and gonapophyses.

*Ormosia (Ormosia) serridens* Alexander, 1919.—Greenbrier, 2,000 ft., March 12, 1939; May 3, 1938 *(Williams)*.

*Ormosia (Ormosia) adirondacensis* Alexander, 1919.—Anakeesta Ridge, 4,000 ft., June 12; 3,300 ft., common among dense beds of dog-hobble, *Leucothoë Catesbaei*, and among tangled vines of *Aristolochia*, June 5; Leconte, Alum Cave trail, 4,000-4,500 ft., June 12, in *Leucothoë* hobbles. Compared with northern specimens, these flies are much lighter in color, pale brownish yellow, yet the male hypopygium confirms the identity.

*Ormosia (Ormosia) brevicalcarata* Alexander, 1927.—Greenbrier, Forks, 1,700 ft., June 7; Brushy Mt. trail, 2,000 ft., June 15; 3,500 ft., September 16 *(Cole & Hickman)*.

**Ormosia (Ormosia) lilliana** sp. nov.

Allied to *dentifera;* general coloration of thorax gray; antennae black throughout; legs brownish black, the femoral bases restrictedly obscure yellow; wings brownish yellow, stigma pale brown; cell *1st* $M_2$ open by atrophy of

basal section of $M_3$; vein *2nd A* gently sinuous; male hypopygium with the inner dististyle strongly narrowed on outer third; gonapophyses appearing as slender curved black horns, at base of each with two or three small teeth.

♂. Length, about 4.2-4.3 mm.; wing, 5-5.2 mm.

♀. Length, about 5 mm.; wing, 5.5 mm.

Rostrum dark brown; palpi black. Antennae short, black throughout, scape more pruinose; flagellar segments oval; longest verticils exceeding the segments. Head gray.

Pronotum and mesonotum uniform light gray, the lateral pretergites restrictedly light yellow; pseudosutural foveae and tuberculate pits black. Pleura pale brownish gray. Halteres yellow. Legs with the coxae and trochanters obscure yellow; remainder of legs brownish black, the femoral bases restrictedly obscure yellow. Wings (Fig. 42) tinged with brownish yellow, the prearcular and costal fields lighter yellow; stigma long-oval, pale brown; veins brown, more flavous in the yellow areas. Macrotrichia abundant in all cells (not indicated in figure). Venation: $Sc_1$ ending about opposite $R_2$; $R_{2+3+4}$ longer than $R_{2+3}$; cell *2nd* $M_2$ deep, *1st* $M_2$ open by atrophy of basal section of $M_3$; *m-cu* erect, close to fork of $M$; *vein 2nd A* gently sinuous.

Abdominal tergites dark brown, sternites obscure brownish yellow; hypopygium yellow. Male hypopygium (Fig. 48) with the apex of basistyle, *b*, produced into a small setiferous lobe (not shown in figure). Outer dististyle, *od*, a flattened ear-shaped structure, darkened on outer half; inner dististyle strongly narrowed on outer third. Gonapophyses, *g*, appearing as long slender curved black horns, at base of each with two or three small teeth.

*Holotype*, ♂, Silers trail, 6,000 ft., June 6, 1939 *(C. P. Alexander)*. *Allotopotype*, pinned with a paratype ♂. *Paratopotypes*, 6 ♂ ♀, with the types, 5,800-6,300 ft., June 6, 1939 and June 17, 1940, in both North Carolina and Tennessee; 1 ♀, Indian Gap, 5,500 ft., June 9, 1939 *(C. P. Alexander)*.

This distinct species of *Ormosia* is named in honor of Mrs. Lillie Schreiber Harrison (Mrs. Walter H. Harrison), who has been our colleague on many camping trips throughout the extent of the Appalachian system. In my field notes, I had tentatively determined this fly as being *Ormosia (Ormosia) dentifera* Alexander, of northeastern North America, which it closely resembles and which is its nearest ally. The structure of the male hypopygium is quite distinct in the two flies, especially the inner dististyle and the gonapophyses. In *dentifera*, the gonapophyses are much stouter, with one or more denticles at near midlength, so there is a narrow lower notch between this spine and the base of the apophysis; in the present fly, the denticles are small and placed at the very base of the apophysis.

**Ormosia (Ormosia) harrisoniana** sp. nov.

Allied to *monticola;* antennae of male greatly elongated; general coloration of thorax yellow, the praescutum with three conspicuous brown stripes; wings with a dusky tinge; vein *2nd A* slightly sinuous on distal third; male hypo-

pygium with the tergite conspicuous, its caudal border shallowly and unequally trilobed, the lateral lobes appearing as pale cushions; gonapophyses conspicuously blackened and trilobed, the outermost point obtuse at apex, the others appearing as acute spines.

♂. Length, about 4.5 mm.; wing, 5.5 mm.; antenna, about 3.5 mm.

♀. Length, about 4.5 mm.; wing, 5 mm.

Rostrum and palpi brownish black. Antennae (male) elongate, as shown by the measurements; scape and pedicel pale, flagellum black throughout; flagellum nodulose, the basal swelling of the segments with abundant long outspread setae, the long apical pedicels smooth. Head brownish gray.

Pronotum pale, darker medially. Mesonotal praescutum obscure yellow laterally, with three conspicuous brown stripes, in cases these latter confluent to virtually cover the disk; remainder of notum dark brown. Pleura obscure brownish yellow, the pleurotergite darker. Halteres dusky, the base of stem yellow. Legs with the coxae and trochanters yellow; remainder of legs brown, the tarsi with more golden-yellow vestiture. Wings (Fig. 41) with a dusky tinge, the stigma darker; veins brown. Macrotrichia of cells abundant (not shown in the figure). Venation: Cell *1st* $M_2$ open by the atrophy of the basal section of $M_3$; vein *2nd A* slightly sinuous on distal third.

Abdomen, including hypopygium, dark brown or brownish black. Male hypopygium (Fig. 47) with the tergite conspicuous, the caudal border shallowly and unequally trilobed, pale, the lateral lobes obtuse. Dististyles, *id*, *od*, much as in *monticola;* outer style narrowed at apex, the distal half with abundant delicate setulae; inner style narrowed at apex. Gonapophyses, *g*, heavily blackened, with three points instead of two as in *monticola;* inner pair acute spines, the outer lobe longer and stouter, its apex obtuse.

*Holotype*, ♂, Mount Leconte, near Huffs Lodge, 6,400 ft., August 8, 1939 *(Mrs. J. Huff)*. *Allotopotype*, ♀, pinned with type. *Paratype*, ♂, Brushy Mt. trail, Greenbrier Cove, 3,500 ft., September 16, 1939 *(Cole & Hickman)*.

I take unusual pleasure in naming this species after my long-time friend and fellow camper, Mr. Walter Henry Harrison, of Amherst, with whom we have collected Tipulidae in most sections of the Appalachian Mountains (Gaspé: Shickshocks; White Mountains, N. H.; Green Mountains, Vt.; Adirondacks, N .Y.; the Great Smokies and Mount Mitchell). The fly is most nearly related to *Ormosia (Ormosia) monticola* (Osten Sacken) of northeastern North America, differing most conspicuously in the characters of the male hypopygium, notably of the gonapophyses.

Members of the present genus, *Ormosia* Rondani, are among the most interesting and instructive in the entire family Tipulidae. It should be noted that while Rogers found but a single species, *adirondacensis*, in the Cumberland Plateau region, no fewer than twelve species from the Smokies are here recorded and several others will undoubtedly be discovered as a result of future collecting.

*Tasiocera (Dasymolophilus) ursina* (Osten Sacken, 1859).— Chimneys Camp, 2,700 ft., June 4-8. Near rock-houses, occurring in small dancing swarms along tiny rills flowing from springs along the low cliffs; many hundreds, in small groups of from 15 to 30. Rogers (l.c., p. 5-6, pl. 5, fig. 9) has well described and figured these so-called "rock-houses" as they occur in the Cumberland Plateau.

*Molophilus (Molophilus) auricomus* Alexander, 1926.—Greenbrier, May 22, 1938 *(Williams);* near Forks, 1,800 ft., June 7; Cades Cove, May 8, 1938 *(Williams);* Myers Lodge, 2,000 ft., June 17 *(M. M. Alexander).*

*Molophilus (Molophilus) fultonensis* Alexander, 1916.—Clingmans Dome, 6,400 ft., June 18, common in boggy areas; Chimneys Camp, 2,600 ft., June 11; Cades Cove, Myers Lodge, swept from beds of *Zanthorhiza apiifolia* L'Her. (Ranunculaceae) along Forge Creek, 1,900 ft., June 10. I am unable to satisfactorily separate the present fly from *huron* Alexander or from the manuscript species *cumberlandensis* Alexander (Rogers list, l.c., p. 49) and more material will be needed from all parts of the range to determine the variation in characters.

*Molophilus (Molophilus) pubipennis* (Osten Sacken, 1859).—Greenbrier, May 22, 1938 *(Williams).*

*Molophilus (Molophilus) cramptoni* Alexander, 1924.—Chimneys Camp, near small waterfall, 2,600 ft., June 11.

*Molophilus (Molophilus) hirtipennis* (Osten Sacken, 1859).—Silers trail, 5,800-6,000 ft., June 6; Clingmans Dome, in boggy areas, associated with *Dicranota (Plectromyia) confusa* and *Limnophila cherokeensis,* 6,400 ft., June 18; Anakeesta Ridge, 5,000 ft., June 5; Leconte, Alum Cave trail, 5,500-6,000 ft., June 12; Greenbrier, Brushy Mt. trail, 2,500 ft., May 20 1939 *(Williams).*

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# Species of Tetradium in the Cincinnati Series

Carolyn James

The Cincinnati series contains several corals referred to the genus *Tetradium* Dana. These have been variously cited under the following specific names:

*T. fibratum* Safford 1856—Amer. Jour. Sci., 2d ser., **22**:237, fig. 2.
*T. minus* Nicholson (not Safford) 1875—Rep. Pal. Province Ontario, (2):28.
*T. huronense* Foord (part) 1883—Geol. Surv. Canada, Cont. Micro-Paul.: 25, pl. 7, figs. 1b-1e (not 1, 1a).
*T. approximatum* Ulrich 1888—Amer. Geol., **1**:183 (nomen nudum).

## Species with Small Coralla

*T. fibratum*, the genotype, was described by Safford from rocks of Trenton age. It possesses four-sided corallites with prominent septa. *T. minus* Safford is small and has small corallites. *T. approximatum*, listed by Ulrich with no description, has only Bassler's (U. S. Nat, Mus., Bull. 92, 2:1264-1265, 1915) indirect definition in which he cites several references under the synonymy of this name. These citations include at least two different species, and the name *approximatum* is here restricted to *Tetradium minus* Foerste not Safford (Bull. Sci. Lab. Denison Univ., 14:311, pl. 10, figs. 1a-1b, 1909).

## Species with Large Coralla

Bassler also included under *T. approximatum* the large forms *T. huronense* Foord and *T. minus* Cumings not Safford (Indiana Dep. Geol. Nat. Res., 32nd Ann. Rep.; 709, pl. 2, figs. 1-1c, 1908). These two appear to be identical, and the specific name *huronense* Foord should apply to both.

Fig. 1. *Tetradium drakei*. Holotype. ×1/8. A. Base of corallum. B. Upper surface of corallum.

In addition to *T. huronense*, the Cincinnati series contains another large form here described.

**Tetradium drakei** sp. nov.

*Description of Holotype.*—Corallum forms spreading sublenticular mass 33 to 36.5 cm. in diameter, with the greatest thickness 9.5 cm. The base is irregular in outline, 19 to 22.5 cm. in diameter. Lower surface of corallum rises 3 to 5 cm. above the central part of the base. It is without epitheca, and the corallites are usually grouped to produce irregular radial flutings on the under surface. The upper surface of the corallum is flattened over an area 25 cm. in diameter, beyond which it slopes abruptly to the edge. It is moderately smooth with corallites distinctly visible.

The corallites are roughly prismatic in shape, ranging from about .5 mm. to about 1.2 mm. in diameter. In longitudinal section the walls show moderate crenulations. Most of the corallites are closely appressed, but occasional mud-filled interspaces occur. The double character of the walls between contiguous

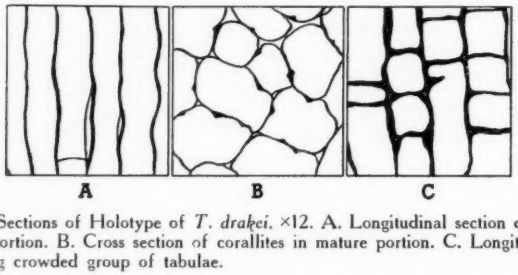


Fig. 2. Sections of Holotype of *T. drakei*. ×12. A. Longitudinal section of corallites in mature portion. B. Cross section of corallites in mature portion. C. Longitudinal section showing crowded group of tabulae.

corallites is not always apparent. Cross sections of the corallites are irregularly polygonal with somewhat rounded angles. The septa when present are rudimentary, usually appearing as minor thickenings of the corallite wall. They are better developed in the neighborhood of tabulae. They appear to be entirely absent in the mature portion of some corallites. Straight tabulae sometimes occur in crowded groups, but are otherwise rare. Multiplication of corallites is infrequent in the adult portion.

*T. drakei* differs from *T. huronense* Foord in having thinner walls and much less prominent septa in the mature corallites.

*Occurrence.*—The intermittent stream valley behind the school at Genntown, Morrow Quadrangle, Ohio, elevation 920 feet. Ordovician, upper Richmond group.

*Holotype.*—Number 4753, Vassar College Museum of Geology.

VASSAR COLLEGE,
POUGHKEEPSIE, N. Y.

# Schmaltzia

Fred A. Barkley

It seems desirable at this time to bring the nomenclature of this genus up to date, since further studies have convinced the author that this group should be considered as a genus, rather than as a subgenus as provisionally treated in his previous study of the group.[1]

The contrast between *Rhus* in the narrower sense and *Schmaltzia* is most conspicuously displayed in the inflorescence, which in the former is a compact thyrsus bearing many flowers, each of which is subtended by a lanceolate, caducous bract and in the latter is a group of spikes or less commonly a group of racemes with the flowers each subtended by a persistent more or less deltoid bract and two similar bracteoles. The exception to this type of inflorescence in *Schmaltzia* is that of *S. Lentii* which has a coarse terminal panicle quite unlike that of *Rhus*, and in which the bracts are deciduous. The inflorescence appears after the leaves in *Rhus* while it appears with or before the leaves in *Schmaltzia*.

In both genera the plants are shrubs or small trees, although in *Schmaltzia* several species are subcandent. The branches of *Rhus* are usually few, and rather thick, as contrasted to the many, slender branches typical of *Schmaltzia*. Heimsch in his excellent study[2] has shown that in the wood of the species of the former which he has examined, resin canals are absent in the wood rays and the wood rays themselves are from two to four cells wide, while in the two species of the latter which he studied, resin canals were found to be present in the rays and the wood rays themselves were one to two cells wide.

The fruits of the two genera usually have a similar appearance, but their pubescence differs consistently, that of *Schmaltzia* being red glandular and hyaline hairs intermixed, and that of *Rhus* red glandular hairs intermixed with deeply red-stained ones.

In his study of the pollen, Heimsch *(l.c.)* found that the pollen of the two genera were in marked contrast as regards surface characters; the pollen coats of the *Rhus* species are reticulate or striate, while those of *Schmaltzia* are generally smooth and in the few species where striations do occur they are faint and widely spaced.

Three elements of *Schmaltzia* have been variously proposed as generic segregates by Rafinesque, Nuttall, Greene, and others (*cf.* Barkley, *l.c.*, Tab. I). In each case the morphological divergence from *Rhus* was noted, but the

1 Barkley, Fred A. A monographic study of *Rhus* and its immediate allies in North and Central America, including the West Indies. Ann. Mo. Bot. Gard. **24**:265-498. pls. 16. 1937.

2 Heimsch, Charles, Jr. Wood anatomy and pollen morphology of *Rhus* and allied genera. Journ. Arn. Arb. **21**:279-291. pls. 3. 1940.

similarity to the other elements of *Schmaltzia* was for the most part overlooked. Gray[3] alone, seems to have realized their mutual relationship.

Since the history, morphology, specific delimitation, geographic distribution, and economic uses have been previously discussed by the author (Barkley, *l.c.*) they are omitted from this paper.

This study was made possible by a grant-in-aid from the Penrose fund of the American Philosophical Society. The author is also indebted to Mr. Merton J. Reed for his assistance on much of the work included in this paper and to the directors and curators of the herbaria where the material cited has been studied.

In using the following outline, reference to the previous paper (Barkley, *l.c.*) will give complete synonymy, descriptions of the elements, and additional exsiccatae; it seemed advisable to limit this treatment to necessary synonymy, recent synonymy and to the citation of specimens studied since the completion of the monograph.

The herbaria from which material has been studied and from which specimens are cited are indicated by the following abbreviations:

Ariz—University of Arizona Herbarium
Cath—Catholic University of America Herbarium
CA—California Academy of Sciences Herbarium
Calif—University of California Herbarium, Berkeley
CalLA—University of California Herbarium, Los Angeles
F—Field Museum of Natural History Herbarium
Idaho—University of Idaho Herbarium, Moscow
IdahoSB—Universityof Idaho Herbarium, Pocatello
Louisiana—Louisiana State University Herbarium
Mich—University of Michigan Herbarium
Minn—University of Minnesota Herbarium
Mont—Montana State University Herbarium, Missoula
MontSC—Montana State College Herbarium, Bozeman
ND—University of Notre Dame Herbarium
NY—New York Botanical Garden Herbarium
PA—Herbarium of the Academy of Natural Sciences of Philadelphia
Penn—University of Pennsylvania Herbarium
Texas—University of Texas Herbarium, Austin
Tulane—Tulane University Herbarium, New Orleans
US—United States National Herbarium
USAgr—United States Department of Agriculture Herbarium in the Bureau of Plant Industry
Wash—Washington State University Herbarium, Seattle
WashSC—Washington State College Herbarium, Pullman

## SCHMALTZIA

*Schmaltzia* Desv., emend. Barkley & Reed.
Desv., Journ. de Bot. Appl. **1**:229. 1813; Barkley & Reed, Amer. Midl. Nat. **24**:672. 1940; Barkl. Ann. Mo. Bot. Gard **24**:341. 1937, as subgenus.

### Section PSEUDOSUMAC

PSEUDOSUMAC Barkl., Ann. Mo. Bot. Gard. **24**:343. 1937, under *Rhus*, subgenus SCHMALTZIA.

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3 Gray, A. Anacardiaceae. In Gray, A. (S. Watson and B. L. Robinson). Synoptical flora of North America **1**(1):381-386. 1897.

1. **Schmaltzia Hartmanii** (Barkl.) n. comb.

*Rhus Hartmanii* Barkl., Ann. Mo. Bot. Gard. **24**:344. 1937.

2. **Schmaltzia jaliscana** (Standl.) Barkl., n. comb.

*Rhus jaliscana* Standl., Contr. U. S. Nat. Herb. **20**:219. 1919; Barkl., Ann. Mo. Bot. Gard. **24**:345. 1937.

3. **Schmaltzia Arsenei** (Barkl.) Barkl., n. comb.

*Rhus Arsenei* Barkl., Ann. Mo. Bot. Gard. **24**:346. 1937.

4. **Schmaltzia Galeottii** (Standl) Barkl., n. comb.

*Rhus Galeottii* Standl., Field Mus. Bot. Ser. **11**:163. 1936; Barkl., Ann. Mo. Bot. Gard. **24**:348. 1937.

5. **Schmaltzia rubifolia** (Turcz.) Barkl., n. comb.

*Rhus rubifolia* Turcz., Bull. Soc. Nat. Moscou **31**(1):470. 1858; Barkl., Ann. Mo. Bot. Gard. **24**:349. 1937.

5a. **Schmaltzia rubifolia** var. **subcordata** (Turcz.) Barkl., n. comb.

*Rhus rubifolia* var. *subcordata* (Turcz.) Engler in DC., Monogr. Phaner. **4**:393. 1883; Barkl., Ann. Mo. Bot. Gard. **24**:349. 1937.

6. **Schmaltzia Barclayi** (Hemsl.) Barkl., n. comb.

*Rhus Barclayi* (Hemsl.) Standl., Contr. U. S. Nat. Herb. **20**:218. 1919; Barkl., Ann. Mo. Gard. **24**:350. 1937.

MEXICO:—JALISCO: Arroyo Seco Canyon, trail from San Sebastian to Arroyo Seco, Sierra Madre Occidental, alt. 1500 m., Jan. 8, 1927, *Mexia 1433* (CalLA, Minn. USAgr.). TEPIC: Sierra de Nayarit, Feb. 10, 1927, *Jones 23130* and Feb. 14, 1927, *22886* (Cath).

7. **Schmaltzia Palmeri** (Rose) Barkl., n. comb.

*Rhus Palmeri* Rose, Contr. U. S. Nat. Herb. **1**:95. 1891; Barkl., Ann. Mo. Bot. Gard. **24**:351. 1937.

MEXICO:—CHIAPAS: Cascada, Siltepec, August 5, 1937, *Matuda S-190* and August 4, 1937, *1671* (Mich).

GUATEMALA:—HUEHUETENANGO: San Miguel Acatan, el. 6300 ft., August 19, 1934, *Skutch 1015* and August 9, 1934, *1602, 1603* (F).

9. **Schmaltzia terebinthifolia** (Schlecht. & Cham.) Barkl., n. comb.

*Rhus terebinthifolia* Schlecht. & Cham., Linnaea **5**:600. 1830; Barkl., Ann. Mo. Bot. Gard. **24**:353. 1937.

MEXICO:—PUEBLA: convalles torrentis La Mesa, ne convalle, regio Huachinango, el. 1000 m., Feb. 15, 1932, *Fröderström & Hultén 961* (F, Mich) and el. 1300 m., Sept. 12, 1932 (Mich).

GUATEMALA:—ALTA VERAPAZ: in scrub, Cobán, alt. 4000 ft., August 28, 1920, *Johnson 628* (CalLA); Cobán, alt. 1350 ft., Jan. 1908, *von Türckheim 1506* (Mich). QUICHÉ: Nebaj, alt. 6700 ft., Dec. 10, 1934, *Skutch 1884* (F).

HONDURAS: Tegucigalpa, Mont de la Flor, alt. 3200 ft., "Agrillo," Dec. 1937, *C. & W. von Hagen 1149* (F).

9a. **Schmaltzia terebinthifolia** var. **Loeseneri** (Barkl.) Barkl., n. comb.

*Rhus terebinthifolia* var. *Loeseneri* Barkl., Ann. Mo. Bot. Gard. **24**:354. 1937.

Section STYPHONIA (Nutt.) Barkl.

STYPHONIA Barkl., Ann. Mo. Bot. Gard. **24**:355. 1937, under *Rhus*, subgenus SCHMALTZIA.

10. **Schmaltzia Lentii** (Kellogg) Barkl., n. comb.

*Rhus Lentii* Kellogg, Proc. Calif. Acad. Sci. **2**:16. 1863; Barkl., Ann. Mo. Bot. Gard. **24**:357. 1937.

MEXICO:—LOWER CALIFORNIA: Cedros Island, March-June 1897, *Anthony 305* (Minn).

11. **Schmaltzia mollis** (H.B.K.) Barkl., n. comb.

*Rhus Standleyi* Barkl., Ann. Mo. Bot. Gard. **24**:358. 1937.

MEXICO:—OAXACA: Calcareous hills near Oaxaca, alt. 6000 ft., August 1894, *Pringle 4815* (Mich).

12. **Schmaltzia Muelleri** (Standl. & Barkl.) Barkl., n. comb.

*Rhus Muelleri* Standl. & Barkl., Ann. Mo. Bot. Gard. **24**:359. 1937.

MEXICO:—Northeastern Mexico, 1937, *Kenoyer 83* (F). NUEVO LEON: Mountains near Monterrey, July 1933, *C. H. & M. T. Mueller 328* (Texas). COAHUILA: Municipio de Castaños, northwest slopes of Sierra San Lazaro, June 18, *Wynd & Mueller 169* (US).

13. **Schmaltzia integrifolia** (Nutt. ex Torr. & Gray) Barkl., n. comb.

*Rhus integrifolia* (Nutt. ex Torr. & Gray) Benth & Hook. f. ex Rothr. in Wheeler's Rept. U. S. Geogr. Surv. **6**:84. 1878; Barkl., Ann. Mo. Bot. Gard. **24**:360. 1937.

UNITED STATES:—CALIFORNIA: Claremont, April 1, 1904, *Baker 4156* (Mich); San Diego, San Diego County, March 10 & April 27, 1902, *Brandegee 818* (CA, Mich); La Jolla, Feb. 23, 1914, *F. E. & E. S. Clements 188* (Mich); southern California, April 1884, *Cleveland* (Mich); Pelican Bay, Santa Cruz Island, June 10, 1930, *Clokey 4994* (Cath, Minn); coast road southeastern Ventura County, alt. 15 m., *Clokey & Templeton* and Mandeville Canyon, Santa Monica Mountains, Los Angeles County, *4605* (Cath, Minn, Mont); Claremont, May 3, 1927, *Craig 314* (Mont); Redondo Beach, July 10, *Davidson 2506* (Mich); San Diego, March 14, 1891, *Dunn* (Minn); Santa Barbara County, May 1902, *Elmer 3898* (Minn); cliffs over ocean, near Clifton, March 1925, *Epling 6462* (CalLA); Griffith Park, May 1925, *M. & C. Epling* (CalLA); Santa Monica Mountains, Los Flores Canyon, March 28, 1930, *Epling & Ellison* (CalLA, Mont); San Clemente Island, March 25, 1918 *Evermann* and Santa Catalina Island, March 29, 1918 (CA); Santa Barbara, *Fauntleroy* (CA); Hamilton Canyon, Santa Catalina Island, Los Angeles County, March 18, 1931, *Fosberg S4286* (Cath), Prisoners Harbor, Santa Cruz Island, Santa Clara County, March 6, 1932, *7625* (CalLA); Garvanza, May 1902, *Grant 1120* and Santa Monica, July 1902, *1118* (Ariz); Coronoda Strand, Aug. 22, 1922, *Harris C22807* (Minn); cañons, Los Angeles, April 25, 1888, *Hasse* and hillsides, Los Angeles County, April & July 1890 (Minn); Cahuenga Hills west of Hollywood Lake, Los Angeles County, March 9, 1929, *Hilend & Kinsel* (CalLA); Santa Ana Cañon, Orange County, alt. 8000 ft., July 29, 1927, *Howell 2870* and Anacopa Island, May 19, 1928, *3813* (CA); Sec. 6, t. 5 N, R. 15 w, San Francisco Cañon, Los Angeles County, *Lewis* (USAgr); lower hills, alt. 360-400 m., San Bernardino Valley, April 4, 1908, *Parish 6890* (Mich, Texas); San Diego County, Dec. 15, 1928, *H. E. & S. T. Parks 0328* (Minn); Feb. 1, 1899, *Spaulding* (Mich); Catalina Island, Sept. 15, 1894, *Toumey* (Ariz);

Santa Catalina Island, 1898, *Trask* (Minn); Claremont, Los Angeles County, June 17, 1933, *Wheeler 1862* (CA); slopes near Torrey Pines Park, San Diego County, June 17, 1928, *Wiggins 3285* (CalLA).

MEXICO:—LOWER CALIFORNIA: Cedros Island, July & Oct., 1896, *Anthony 98* and March & June 1897, *318A* (Minn); San Quintin, April 7, 1936, *Epling & Stewart* (CalLA); Coronados Island, June 4, 1889, *Pond* (Greene at ND); hillsides northeast of Ensenada, el. 200-400 ft., Feb. 23, 1930, *Wiggins 4226* and Santa Maria plains and low hills nearby, 23 miles south of Hamilton Ranch, March 3, 1930, *4325* (Calif, CA); seaward slopes 2 miles south of Halfway House, 37 miles south of Tia Juana, Sept. 8, 1929, *Wiggins & Gillespie 3905* (Mich).

13a. **Schmaltzia integrifolia** var. **cedrosensis** (Barkl.) Barkl., n. comb.

*Rhus integrifolia* var. *cedrosensis* Barkl., Ann. Mo. Bot. Gard. **24**:363. 1937.

14. **Schmaltzia Kearneyi** (Barkl.), Barkl., n. comb.

*Rhus Kearneyi* Barkl., Ann. Mo. Bot. Gard. **24**:363. 1937.

15. **Schmaltzia ovata** (Wats.) Barkl., n. comb.

*Rhus ovata* Wats., Proc. Am. Acad. **20**:358. 1885; Barkl., Ann. Mo. Bot. Gard. **24**:365. 1937.

UNITED STATES:—ARIZONA: Safford, *Soil Conservation Service 923* (Ariz); Globe, Oct. 1913, *Bailey* (Ariz); side valley above Fish Creek, 65 miles east of Phoenix, alt. 3000 ft., Dec. 1913, *Barber* (Mich); in hills between Cherry and Camp Verde, Aug. 20, 1935, *Benham* (Ariz); lower Oak Creek Canyon, August 13, 1936, *Brinkerhoff* (Ariz); Globe, Oct. 1913, *Chadwick* (Ariz); Roosevelt Dam, August 3, 1910, *Goodding 719* (Ariz); Coconino Range, Oct. 11, 1912, *Hill 413* (Ariz); Oak Creek, San Francisco Mountain, Dec. 1906, *Mr. & Mrs. Hockenderfer* (Ariz); Oak Creek, June 1883, *Rusby 548* (Mich); Collom Camp, Matzatzal Mountains, Gila County, alt. 1200 m., *Collom 297* (Cath); the Rim, Oak Creek, near Flagstaff, Aug. 1907, *Thornber 4131, 4137* and Miami, Dec. 29, 1912 (Ariz); Cold Water Cañon, Santa Ana Mountains, 1904, *Zumbo 414* (Ariz).

CALIFORNIA: Banner Grade, San Diego County, April 1933, *Anderson* (CalLA); Mandeville Canyon, Santa Monica Mountains, May 30, 1930, *Anderson & Epling* (CalLA, Mont); hills near Monrovia, April 2-30, 1903 (Mich); Morongo Pass, Riverside County, June 1929, *Braunton 1026* (Cath); alluvial bottom, Mandeville Canyon, Santa Monica Mountains, Los Angeles County, alt. 200 m., April 1929, *Clokey & Templeton 4431* (Mont); 2 miles east of Pinyon Flat, Santa Rosa Mountains, Riverside County, el. 3500 ft., July 3, 1935, *Duran 3498* (Ariz, CalLA, Cath); Topongo Canyon, May 18, 1926, *Epling* and Ridge Route near summit, May 1927 (CalLA); San Gabriel Mountains, Swartout Valley, May 16, 1931, *Epling, Dunn & Goen* (CalLA); Topongo Canyon, Santa Monica Mountains, May 18, 1929, *Epling & Ellison* (CalLA, Mont); Santa Catalina, Los Angeles County, alt. 150 m., May 7, 1932, *Fosberg 8150* and alt. 130 m., *8160* (CalLA); Santa Cruz Island, July & Aug., *Greene* (PA); Tehachepai Pass, Kern County, April 1933, *LaMotte* (Wash); Sec. 31, t. 6 N, R 15 W, La Brun, Angeles Forest, Los Angeles County, alt. 2000 ft., *Lewis* (USAgr); foothills at Redlands, San Bernardino County, April 20, 1891, *Parish* (WashSC), lower hills, Reche Canyon, San Bernardino Valley, alt. 360-400 m., *6801* (Mich) and *6802* (Texas); Santa Ana Mountains, April 16, 1938, *Pequegnat* (CalLA); Santa Catalina Island, Jan. & Feb. 1903, *Saunders* (PA); Santa Catalina, Feb. 3, 1899, *Spaulding* (Mich), and Banner Road, Oct. 31, 1906 (Ariz); 2 miles southwest of Girard, Santa Monica Mountains, Los Angeles County, alt. 1400 ft., Nov. 11, 1931, *Wheeler 341* and San Gorgonia Pass, Riverside County, Dec. 1, 1933, *2280* (CalLA); 5 miles above Alpine, San Diego County, March 20, 1926, *Wiggins 2048* (CalLA); 1.5 miles below Trabuco Camp ground, Trabuco Canyon, west slope of the Santa Ana Mountains, March 6, 1931, *Wolf 1857* (CalLA, Mont).

MEXICO:—LOWER CALIFORNIA: Mountains, Sept. 11, 1887, *Orcutt* (Mich) and Palm Valley, March 8, 1885 (PA).

15a. **Schmaltzia ovata** var. **Traskiae** (Barkl.) Barkl., n. comb.

*Rhus ovata* var. *Traskiae* Barkl., Ann. Mo. Bot. Gard. **24**:368. 1937.

PSEUDOSCHMALTZIA Barkl., Ann. Mo. Bot. Gard. **24**:369. 1937, under *Rhus*, subgenus SCHMALTZIA.

16. **Schmaltzia chondroloma** (Standl.) Barkl., n. comb.

*Rhus chondroloma* Standl., Field Mus. Bot. Ser. **11**:164. 1936; Barkl., Ann. Mo. Bot. Gard. **24**:370. 1937.

MEXICO:—OAXACA: "Shrub to 1 m., fruit orange-red," between Tlaxioco and Teposcalula, Dec. 20-23, 1936, *Camp 2320* (NY); called "Rhus miahuatlana," San Luis Amatlan, August 20, 1937, *Ruiz 35390* (NY).

17. **Schmaltzia Duckerae** (Barkl.) Barkl., n. comb.

*Rhus Duckerae* Barkl., Ann. Mo. Bot. Gard. **24**:371. 1937, as *R. Duckeri* in error.

18. **Schmaltzia pachyrrhachis** (Hemsl.) Barkl., n. comb.

*Rhus pachyrrhachis* Hemsl., Biol. Cent.-Am. Bot. **1**:218. 1880, in part; Barkl., Ann. Mo. Bot. Gard. **24**:373. 1937.

MEXICO:—NUEVO LEON: Sierra Madre Oriental, beyond Pablillo toward Santa Clara, about 15 miles southwest of Galeana, July 18, 1934, *C. H. & M. T. Mueller 1072* and Sierra Madre Oriental, lower San Francisco Cañon about 15 miles southwest of Galeana, July 15, 1934, *1030* (F, Texas). HIDALGO: Jacala, August 13, 1937, *Edwards 779* (F, Texas); Jacala, alt. 4800 ft., Aug. 12, 1937, *Fisher 37209* (F). SAN LUIS POTOSI: Alvarez, Sept. 5-10, 1902, *Palmer 61* (USAgr); 220° N. lat., alt. 6000-8000 ft., 1878-1879, *Parry & Palmer 125* (US); in montibus, 1879, *Schaffner 355* (Mich).

19. **Schmaltzia vestita** (Loesen.) Barkl., n. comb.

*Rhus vestita* Loesen., Bull. Herb. Boiss. II. **6**:835. 1906; Barkl., Ann. Mo. Bot. Gard. **24**:374. 1937.

GUATEMALA:—HUEHUETENANGO: Chiantla, el. 6900 ft., Dec. 15, 1934, *Skutch 1955* (F).

19a. **Schmaltzia vestita** var. **Ghiesbreghtii** (Barkl.) Barkl., n. comb.

*Rhus vestita* var. *Ghiesbreghtii* Barkl., Ann. Mo. Bot. Gard. **24**:375. 1937.

MEXICO: between Arriaga and Pochucalco, Aug. 21, 1926, *Juzepczuk 184f* (F).

20. **Schmaltzia Nelsonii** (Barkl.) Barkl., n. comb.

*Rhus Nelsonii* Barkl., Ann. Mo. Bot. Gard. **24**:375. 1937.

21. **Schmaltzia oaxacana** (Loesen.) Barkl., n. comb.

*Rhus oaxacana* Loesen., Bull. Herb. Boiss. II. **6**:834. 1906; Barkl., Ann. Mo. Bot. Gard. **24**:376. 1937.

MEXICO:—OAXACA: Shrub 3 m. high, between Tlaxiaco & Teposcolula, Dec. 20-23, 1936, *Camp 2315* (NY); calcarious hills, Domingillo Cañon, Nov. 2, 1894, *Pringle 5655* (Mich).

22. **Schmaltzia virens** (Lindh. ex Gray) Small, Fl. Southeast. U. S., pp. 729, 1334. 1903, and ed. 2. 1913.

*Rhus virens* Lindh. ex Gray, Bost. Jour. Nat. Hist. [Pl. Lindh. II] **6**:159. 1850; Barkl., Ann. Mo. Bot. Gard. **24**:377. 1937.

UNITED STATES:—TEXAS: Fort Tyler, Burnett County, Sept. 4, 1921, *Ashe* (Cath); Glass Mountains, *Beckman* (Texas); Pulliam Bluff, July 26, 1925, *Berkman* (Texas); Georgestown, Williamson County, Oct. 2, 1891, *Bodeau 132* (Minn); Scenic Loop, Bexar County, Sept. 18, 1931, *Clare 381* (Cath); Davis Junction, April

12, 1930, *Jones 25653* (CA); Comanche Springs, New Braunfels, Oct. 1850, *Lindheimer 729* (Ariz, Texas), 1849-1851, *730* (Cath, Texas) and Comanche Springs, New Braunfels, Nov. 1849, *731* (Ariz, Texas); top of Mount Bonnel, Austin, Nov. 3, 1900, *Long* (Texas); Boerne, May 15, 1910, *Mackensen* (Mich); Chisos Mountains, Aug. 8, 1931, *Mueller 8065* (Mich, Texas); near the Pecos River, 10 miles east of Ft. Lancaster, April 11, 1900, *Oberholzen* (Texas); foothills of Davis Mountains, Ft. Davis, Jefferson Davis County, Oct. 8, 1926, *Palmer 32109* (Texas); near the Mexican Boundary, Guadalup Mountains, Culberson County, Nov. 5-8, 1922, *Pilsbry* and 6 miles north of Van Horn, Culberson County, Nov. 15-16, 1922 (PA); Gritzeit Ranch, Scenic Loop, San Antonio, Sept. 9, 1917, *Schulz* (Mich); Pine Springs, Guadalupe Mountains, Nov. 21, 1931, *Whitehouse* (Texas); west of San Angelo, Travis County, Dec. 1910, *Winkler 3338* (Texas); near Davis, Oct. 15, 1908, *H. W. Y. 227* (Texas); foothills of Chenate Mountains, Sept. 11, 1914, *Young*, Ft. Davis, Sept. 16, 1918 and Limpia (Texas). NEW MEXICO: Jorando ranch, 17 miles north of Las Cruces, Dona Ana County, Sept. 28-29, 1922, *Pilsbry* (PA).

MEXICO:—chiefly in the valley of the Rio Grande bella Donana, *Parry, Bigelow, Wright & Schott 155* (PA). CHIHUAHUA: Los Organos, Sept. 8, 1937, *Le Sueur 1366* (F). COAHUILLA: Rancho Aqua Dulce, Municipio de Muzquiz, July 1, 1936, *Wynd & Mueller 396* (Cath). NUEVO LEON: Base Chipique, Oct. 9, 1937, *Kenoyer 360* and Chipique, Sept. 25, 1937 (F); west wall of Cañon de Potrero Redondo, Municipio de Villa, July 4, 1935, *Mueller 2109* (Texas); Sierra Madre Mountains near Monterrey, Aug. 23, 1933, *C. H. & M. T. Mueller 95* and Sierra Madre Oriental, descent from the two Puertos, El Cercado, about 30 miles south of Monterrey, Aug. 15, 1934, *1348* (F, Texas).

23. **Schmaltzia choriophylla** (Woot. & Standl.) Barkl., n. comb.

*Rhus choriophylla* Woot. & Standl., Contr. U. S. Nat. Herb. **16**:146. 1913; Barkl. Ann. Mo. Bot. Gard. **24**:378. 1937.

UNITED STATES:—TEXAS: San Antonio, Jan. 1922, *Meure* (CA); Guadalupe Mountains, Culbertson County, Nov. 5-8, 1922, *Pilsbry* (PA); Mount Franklin, El Paso, Dec. 1, 1931, *Whitehouse* (Texas). NEW MEXICO: in limestone debris, bottom of canyon on west slope, Pyramid Peak, Dona Ana County, lower Sonoran zone, alt. 1430 m., Aug. 21, 1930, *Fosberg S3813* (Cal, Cath, Penn); Alamo Canyon, Sacramento Mountains, Otero County, Oct. 8-10, 1922, *Pilsbry* (PA); dry cañon, Sacramento Mountains, Otero County, alt. 4600 ft., April 7 & May 24, 1902, *Rehn & Viereck* (PA); near the mouth of Alamo Cañon, Sacramento Mountains, May 26, 1932, *Wilkens 2136A* (PA); 1851, *Wright* (PA); Organ Mountains, Dona Ana County, Oct. 4, 1903, *Wooton* (Ariz).

ARIZONA: Red Mountain, Patagonia Mountains, Santa Cruz County, alt. 5000 ft., Feb. 13, 1923, *Bartram* (PA); Bonita Canyon, Chiricahua Mountains, Nov. 2, 1906, *Blumer 1323* (Ariz, Minn); Canyon, Santa Rita Mountains, near Tucson, March 22, 1919, *Eastwood 8102* and on road from Tucson to Patagonia, March 15, 1930, *17777* (CA); Portal to Paradise, Chiricahua National Forest, Cochese County, 1600-1730 m. el., Sept. 17-19, 1914, *Eggleston 10647* (USAgr); Tanner Canyon, Huachuca Mountains, Aug. 24, 1910, *Goodding 813* (Ariz); Cottonwood Canyon, Tumicacori Mountains, June 18, 1931, *Hilend 786* (CalLA); Bowie, Sept. 21, 1884, *Jones 4321* (Ariz); Washington, Patagonia Mountain, Sept. 16, 1934, *Kearney & Peebles 10141* (CA); Cave Creek Canyon, Chiricahua Mountains, 7000± ft. el., June 26-29, 1927, *Kusche* (CA); Guadalupe Canyon, Aug. 16, 1892, *Mearns 699* (US); Big Emigrant Canyon, Chiricahua Mountains, Nov. 3-30, 1906, *Pilsbry* and desert northwest of Ceno, Pima County, Sept. 23, 1910 (PA) and Santa Rita Mountains, Sept. 9, 1884, *Pringle 348* (Cath, PA); Lonoita Valley, west of the 100th Meridian, alt. 5700 ft., August 1874, *Rittwoch 645* (PA); Rosemont, Pima County, alt. 5000 ft., March 25, 1917, *Shreve 5124* (Calif); Ranger Canyon, Dragon Mountains, April 11, 1926, *Taylor* (CA); Stone Cabin Canyon, Santa Rita Mountains, June 23, 1903, *Thornber*, July 6, 1903, Tombstone, Aug. 31, 1905, Bowie, Dec. 13, 1914, *7010*, and Rosemont, Sept. 10, 1915, *8115* (Ariz); Huachuca Mountains, March 23,

1894, *Toumey*, Santa Rita Mountains, July 27, 1894, and Clearcreek Canyon, Chiricahua Mountains, July 28, 1894 (Ariz); Fort Heuachuca, June 1894, *Wilcox* (Mich).
MEXICO:—CHIHUAHUA: Santa Eulalia Mountains, Oct. 16, 1885, *Pringle* (PA). SONORA: 11 miles west of Cucurpe, Sept. 13, 1934, *Shreve 6647* (F).

24. **Schmaltzia Andrieuxii** (Engler in DC.) Barkl., n. comb.

*Rhus Andrieuxii* Engler in DC., Monogr. Phaner. **4**:389. 1883; Barkl., Ann. Mo. Bot. Gard. **24**:379. 1937.

MEXICO: Oct. 1881, *Havard* (Mich); April 1926, *Runyon & Tharp 852* (Texas). COAHUILA: Mountains 6 miles east of Saltillo, July 17-20, 1880, *Palmer 190* (PA). NUEVO LEON: shrub 10 feet tall, Hacienda Ojo de Aqua on Cerro Potosi, Galeana, alt. 7200 ft., Aug. 19, 1938, *Schneider 1007* (F). OAXACA: Cañon of the Rio Tlahuitoltepec, Feb. 19-27, 1937, *Camp 2706-II* and between Tlaxiaco and Teposcolulo, Dec. 20-23, 1936, *2321* (NY). TAMAULIPAS: near Juamave, Dec. 5, 1931, *von Rozynski 244* (CalLA) and Sierra near Jaumave, *245* (Mich).

25. **Schmaltzia Schiedeana** (Schlecht.) Barkl., n. comb.

*Rhus Schiedeana* Schlech., Linnaea **16**:480. 1842; Barkl., Ann. Mo. Bot. Gard. **24**:380. 1937.

GUATEMALA: in hills between Giusiltepeque and Potrero Carillo, alt. 1800 m., Dec. 11, 1939, *Steyermark 33027* (F). BAJA VEREPAZ: dry rocky hills north of Santa Rosa, March 30, 1939, *Standley 69760* and *69799* (F).

26. **Schmaltzia Tepetate** (Standl. & Barkl.) Barkl., n. comb.

*Rhus Tepetate* Standl. & Barkl., Ann. Mo. Bot. Gard. **24**:382. 1937.

MEXICO:—CHIHUAHUA: Magnarichic, March 6, 1938, *Knoblock 5039* (F). SONORA: Sierra Charuco, Rio Mayo, Sept. 10, 1935, *Gentry 1746* (Cath. US).

27. **Schmaltzia macropoda** (Barkl.) Barkl., n. comb.

*Rhus macropoda* Barkl., Ann. Mo. Bot. Gard. **24**:383. 1937.

MEXICO:—OAXACA: Cañon of the Rio Tlahuitoltepec, Feb. 19-27, 1937, *Camp 2706-I* (NY).

28. **Schmaltzia ciliolata** (Turcz.) Barkl., n. comb.

*Rhus ciliolata* Turcz., Bull. Soc. Nat. Moscou **31**(1):470. 1858; Barkl., Ann. Mo. Bot. Gard. **24**:384. 1937.

29. **Schmaltzia profusa** (Barkl.) Barkl., n. comb.

*Rhus profusa* Barkl., Ann. Mo. Bot. Gard. **24**:385. 1937.
MEXICO:—SAN LUIS POTOSI: Los Canos, Oct. 15-21, 1902, *Palmer 214* (USAgr).

Section RHOEIDIUM (Greene) Barkl.

RHOEIDIUM (Greene) Barkl. Ann. Mo. Bot. Gard. **24**:386. 1937, under *Rhus*, subgenus SCHMALTZIA.

30. **Schmaltzia microphylla** (Engelm. ex. A. Gray) Small, Fl. Southeast. U. S., pp. 728, 1334. 1903.

*Rhus microphylla* Engelm. ex A. Gray in Smiths. Contr. [Pl. Wright. I] **3**(5):31. 1852; Barkl., Ann. Mo. Bot. Gard. **24**:387. 1937.

UNITED STATES:—TEXAS: Canutillo, Franklin Mountains, El Paso County, July 12, 1911, *Barlo* (CalLA); Ord Mountains, Sterling County, August 17, 1925, *Bink* (Texas); Glass Mountains, *Birkman* (Texas); Comstock, March 21, 1911, *Blair 217* (Mich);

Big Springs, May 23, 1899, *Bray 408* and foothills, Alpine, June 4, 1902 (Texas); 1927, *Carter* (USAgr); entrance to Guadalupe Canyon, Guadalupe Mountains, alt. 5000-6000 ft., May 29-June 4, 1912, *Chase 5921, 5924, 5933,* and open alkali flat north of Van Horn, el. 4500 ft., *6033* (Mich); Medico Creek near Castroville Road Crossing, July 6, 1931, *Clare 95* and Pleasanton Road, 13 miles south of San Antonio, Oct. 26, 1933 (Cath); Sonora Experiment Station, Sutton and Edwards Counties, el. 700 m., July 13, 1920, *Eggleston 16689* (Mich, Texas); Evans Ranch, 25 miles north of Valentine, Jeff Davis County, April 8, 1929, *Ingram 2627* (USAgr); El Paso, April 23, 1884, *Jones 3765* (PA); 1849-1851, *Lindheimer* (Cath), Comanche Springs, New Braunfels, March 1850, *734* (Ariz, Texas), May 1850, *735* (Texas) and *736* (Ariz); mesa west of Mount Livermore, Davis Mountains, Jeff Davis County, el. 1800 m., June 14, 1931, *Moore & Steyermark 3085* (Mich) and arroyo bank, mesa north of Chisos Mountains, Brewster County, June 27, 1931, *3290* (Mich, Minn); Chisos Mountains, Brewster County, Nov. 22-24, 1922, *Pilsbry* (PA); Buffalo Springs, Lubbock, July 13, 1934, *Reed 3821* (Texas); Fort Concho, April 1882, *Reverchon 156* (Penn) and rocky hills, Fort Concho, March-April, *449* (Minn); Mason to Eden, August 3, 1921, *Tharp,* Ord Mountains, August 17, 1925, *3572,* Oak Canyon, Chisos Mountains, June 2, 1931, *8811,* and Buffalo Springs, May 1, 1934 (Texas); plains west of Pecos, April 20, 1902, *Tracy & Earle 112* (Minn, Texas) and April 30, 1902, *112a* (Minn); Limpia Canyon, May 12, 1914, *Young,* Chisos Mountains, August 12, 1915 and August 24, 1916 (Texas).

NEW MEXICO: 4 miles south of Larsberg, August 7, 1906, *Blumer 1858* (Ariz); road between San Marcial and Nogal Canyon; Soccorro County, June 23, 1921, *Ferris & Duncan 2343* (Minn); Peloncillo Mountain, 20 miles northeast of 66 Rodeo, alt. 4000 ft., June 14, 1930, *Goodman & Hitchcock 1146* (Mich, Minn); upper corner monument, Grant County, May 5, 1892, *Mearns 57* (US); Berendo Creek, Grant County, alt. 5000 ft., May 23, 1904, *Metcalfe 924* (Minn); chiefly in the Valley of the Rio Grande, below Donana, *Parry, Bigelo, Wright & Schott* (US); Jornado ranch, 17 miles north of Las Cruces, Dona Ana County, Sept. 28-29, 1922, *Pilsbry* (PA); below Alamogordo and Sacramento Mountains, Otero County, April 8, 1902, *Rehn & Viereck* (CalLA, Cath); on a mesa near Las Cruces, Dona Ana County, alt. 4100 ft., July 1, 1897, *Wooton 68* (Minn) and on mesa west of Organ Mountains, Dona Ana County, April 22, 1899 (Ariz).

ARIZONA: Paradise, Chiricahua Mountains, August 21, 1906, *Blumer 1322* (Cal, Mich, Minn) and Ft. Bowie, Nov. 5, 1906, *2929* (Ariz); near Gleason, Sulphur Springs, August 3, 1935, *Cassedy & Taylor* (Ariz); Waray Canyon, Clifton, May 7, 1889, *Davidson 177* (Mich); plateau near Tombstone, June 9, 1931, *Hilend 673* (CalLA); east of Tombstone, Cochise County, alt. 4539 ft., June 6, 1935, *Hutchinson 6711* (CalLA) and Tombstone, Sept. 1931, *6892* (CalLA); Douglas, April 8, 1930, *Jones 25655* (CalLA, Cath); Paradise to San Simon, May 25, 1928, *Peebles 5435* (CalLA); Pantano, August 16, 1904, *Thornber 544* (Ariz, Cal, Minn), Benson, August 19, 1905, (Ariz, Calif), and mesas near Douglas, Sept. 10, 1913, *7129* (Ariz); Mule Mountains, July 20, 1894, *Toumey* (Ariz).

MEXICO:—CHIHUAHUA: near Chihuahua, alt. 1300 m., April 8-27, 1908, *Palmer 19* (USAgr); May 1885, *Pringle,* rocky hills near Chihuahua, March 20 & May 25, 1885, *171* (Penn) and *894* (Minn); mountains northwest of Chihuahua, June 18, 1936, *Le Sueur 770* (Texas). COAHUILLA: Ramos Arizpe, east of Hacienda La Rosa, June 14, 1936, *Wynd & Mueller 48* (Cath). NUEVO LEON: Sierra Madre Oriental, road from Pablillo to Ceineguillas, about 15 miles southwest of Galeana, June 15, 1934, *C. H. & M. T. Mueller 803A* (F, Texas); Las Trancas, Municipio de Rayones, July 8, 1935, *Mueller* (F). SAN LUIS POTOSI: Charcas, July & August 1934, *Lundell 5308* and *5309* (Mich); 1878, *Parry & Palmer 126* (US). SONORA: Cochuto, alt. 5000 ft., Oct. 5, 1890, *Hartman 79* (Penn). ZACATECAS: Cedro, June 1908, *Kirkwood 201* (Mont).

### Section LOBADIUM

LOBADIUM (Raf.) DC., Prodr. **2**:72. 1825, under *Rhus;* Barkl., Ann. Bot. Gard. **24**:390. 1937, under *Rhus,* subgenus SCHMALTZIA.

31. **Schmaltzia allophylloides** (Standl.) Barkl., n. comb.

*Rhus allophylloides* Standl., Field Mus. Bot. Ser. **4**:220. 1929; Barkl., Ann. Mo. Bot. Gard. **24**:392. 1937.

MEXICO:—JALISCO: Near stream in thicket on steep hillside, trail from San Sebastian Real Alto, Sierra Madre Occidental, el. 2000 m., Feb. 4, 1927, *Mexia 1640* (Calif, CA). SONORA: Cuohui, Rio Mayo, el. 3500 ft., April 5, 1938, *Gentry 3671* (F).

31a. **Schmaltzia allophylloides** var. **Mexiae** (Barkl. & Reed) Barkl. & Reed, n. comb.

*Rhus allophylloides* var. *Mexiae* Barkl. & Reed, Amer. Midl. Nat. **22**:209. 1939.

MEXICO:—GUERRERO: open pine-forested slope, Petlacala, north of Mine Sancta Elena, alt. 1880 m., Dec. 27, 1937, *Mexia 9035* (Calif).

32. **Schmaltzia schmidelioides** (Schlecht.) Barkl., n. comb.

*Rhus schmidelioides* Schlecht., Linnaea **16**:482. 1842; Barkl., Ann. Mo. Bot. Gard. **24**:393. 1937.

32a. **Schmaltzia schmidelioides** var. **potosinensis** (Barkl.) Barkl., n. comb.

*Rhus schmidelioides* var. *potosinensis* Barkl., Ann. Mo. Bot. Gard. **24**:394. 1937.

33. **Schmaltzia crenata** (Mill.) Greene, Leafl. Bot. Obs. & Crit. **1**:130. 1905.

*Lobadium trifoliatum* Raf., Cat. Bot. Gard. Trans. Univ., p. 14. 1824.

*Myrica trifoliata* Printz, Pl. Afr. Rar. (In L., Amoen. Acad. **5**:CVI. p. 77. 1764.) p. 28. 1760 as MYRICA trifoliata foliis ternatis dentatis; hort. ex Steud., Nom. Bot., ed. 2, p. 451. 1841.

*Rhus aromatica* Ait., Hort. Kew. **1**:367. 1789; Barkl., Ann. Mo. Bot. Gard. **24**:394. 1937.

*Rhus aromatica* var. *illinoensis* (Greene) Rehder, Journ. Arn. Arb. **20**:415. 1939.
*Rhus canadense* Marsh., Arbust. Am., p. 129. 1785, non Mill., Gard. Dict., ed. 8. 1768.
*Toxicodendron Crenatum* Mill., Gard. Dict., ed. 8. 1768.

It seems very probable that there has been hybridization between this species and *Schmaltzia trilobata* where their areas overlap. In its westward range the leaves of *S. crenata* become smaller, are more often obtuse and somewhat different in pubescence; however, the sporadic variations found in the species over its range when compared with each other do not seem to this author to be deserving of varietal rank.

CANADA:—ONTARIO: Morpeth, July 3, 1905, *Fisher* (CalLA); Gnelph, July 5, 1906, *Loomis* (CalLA); Queenston Heights, May 16-July 6, 1901, *Macoun* (Penn).

UNITED STATES: *Beasley* (Bartram Herb. in PA); "Southern Trip," 1806, *Pursh* (Bartram Herb. in PA).

VERMONT: Snake Mountain, July 15, 1881, *Brainerd* and May 27, 1882 (Minn); Peon Mountains, Charlottville, May 12, 1878, *Hosfort* (USAgr).

NEW HAMPSHIRE: Hanover bank of the Connecticut River, Oct. 1934, *Wilson* (WashSC).

NEW YORK: Crown Point, July 3, 1923, *Carpenter* (Minn); *Canandaigna*, May 12 & June 6, 1892, *Durand* and July 6, 1893 (Minn); Glen Cove, Long Island, July 29, 1920, *Harshberger* (Penn); Niagara Falls, *Howarth* (Penn); Ashland, June 29, 1882

& May 5, 1884, *Lucy 1419*, and Chemung County, May 6, 1897, *1678* (Minn); Cayuga Heights, May 25, 1931, *Maguire 6460* (WashSC); Genesee County, July 13, 1930, Mathews 3134 (CalLA); 2 miles northeast of Pollsburg, Columbia County, May 19, 1933, *McVaugh 574*, East Nassau, Renso County, August 24, 1933, *2194*, 1 mile east of Greendale Station, Columbia County, Sept. 24, 1932, *2435*, Stockfort, Columbia County, May 30, 1933, *767*, and Stuyvesant, Columbia County, April 22, 1933, *357* (Penn); limestone rocks, north side of Black River, two miles east of Brownville, Jefferson County, July 8, 1931, *Muenscher & Maguire 2381* (Calif); rocky banks along Cayuga Lake, near Ithaca, July 13, 1920, *Muenscher & Bechtel 258* (WashSC); Glens Falls on the Mohock, 1807, *Pursh* (Bartram Herb. in PA); east of Middleburg, Schoharie County, June 13, 1936, *Svenson 7841* (Penn); South Hill and Fall Creek, Ithaca, May 10 & June 6, 1892, *Townsend* (WashSC).

PENNSYLVANIA: 1.5 miles northeast of Shellburg, Bedford, May 8, 1938, *Adams 4304* (Penn); along Conacochcagne Creek near Welch Run, Franklin County, Sept. 12, 1935, *Adams & Wherry 2444* (Penn); along New River, Eggleston, Giles County, Aug. 19, 1937, *Fogg 13346* (Penn); Harrisonville, Fulton County, June 26, 1934, *Lise* (Penn); base of the Alleghany Mountains, Center County, *McMinn* (PA); Delaware County, *Paynter* (Penn); Huntingdon County, 1866, J. C. P. (Penn); .5 miles southeast of Needmore, Fulton County, June 20, 1936, *Wilkens 4745* (Penn).

DISTRICT OF COLUMBIA: Potomac Park, July 5, 1921, *Freeman* (USAgr).

MARYLAND: near Great Falls, Aug. 16, 1888, *Holm* and Harper's Ferry, Oct. 6, 1912 (Cath); Bardwater, April 17, 1908, *Williamson* and May 30, 1909 (Penn).

WEST VIRGINIA: Falling Waters, Berkeley County, May 30, 1937, *Freeman* (USAgr).

VIRGINIA: Natural Bridge, April 28, 1886, *Deane* (Minn); along New River, near Klotz, Giles County, August 5, 1937, *Fogg 13019*, July 8, 1938, *14869*, along Walkers Creek, near Bane, Giles County, June 29, 1938, *14705*, and along New River near Goodwins Ferry, Giles County, July 13, 1939, *14963* (Penn); rich alluvial woods at Goose Creek, Loudown County, June 6, 1937, *Osborn 1854* (Mont); Natural Bridge, 1806, *Pursh* (Smith Herb. in PA); along Roanoke River, Roanoke County, April 13, 1936, *Wherry & Adams 2631* (Penn); near Strasburg, Shenandoah County, Oct. 21, 1934, *Wilkens 3819* (Penn).

NORTH CAROLINA: South New Hope Creek, Duke Forest, Orange County, Sept. 29, 1933, *Blomquist 4130* (Penn).

GEORGIA: area of Fall Line Sand Hills, vicinity of Thomson, McDuffie County, Sept. 9, 1907, *Bartlett 994* (Cath); Stone Mountain, De Kalb County, August 2, 1912, *Pennell 4044* (Penn).

MICHIGAN: gravelly bank, Tecumseh Tp., Lenawee County, July 25, 1916, *Ballington* (MontSC); St. Clair County, May 7 & June 22, 1895, *Dodge 2350* (Minn) and Great Lakes Region, near Port Huron, St. Clair County, June 8, 1899 (Texas).

INDIANA: 6 miles southeast of Brookville, Franklin County, June 17, 1915, *Deam 16064*, 2 miles west of Logansport, Cass County, July 22, 1915, *17833*, southeast of Peru, Miami County, July 23, 1915, *17901* (Minn), about 3 miles east of Elisabeth, Harrison County, Sept. 1, 1937, *58325* (Mont), and just east of Marble Bridge on the south bank of the river, Wells County, May 19, 1901 (Minn).

ILLINOIS: Cook County, Sept., *Moffatt 143* (Minn); the Mounds, Joliet, May 8, 1904, *Skeels 59*, May 20, 1900, and Flathead Mound, Joliet, June 27, 1905 (USAgr).

KENTUCKY: rocky hillsides, Nelson County, Sept. 14, 1933, *Agnes*, and Nelson County, June 17, 1932 (Cath).

ALABAMA: Jackson County, June 26, 1930, *Ashe* (Cath); limestone hills near Huntsville, *Mohr* (USAgr).

LOUISIANA: dry hills, Minden, Webster Parish, July 6, 1934, *Brown 5340* (Louisiana); Nachitoches, March 15, 1911, *Cocks* (Tulane); sandy woods, Natchitoches, April 24, 1915, *Palmer 7362* (Tulane).

MISSOURI: rocky bluffs, Courtney, June 2, 1931, *Bush 12117*, and Oseola, July 28,

1933, *12805* (Minn); Meramec Highlands, April 1910, *Craig* (Mont); Whiteside, Sept. 12, 1911, *Davis 2646*, Hannibal, May 25, 1914 (Texas), and Marion County, May 30, 1914, *2646* (Minn); Columbia, 1922, *Eyster* (Mont); Allenton, 1894, *Letterman* (Texas); Bollinger County, April 26, 1931, *Palmer 39106* (Minn); Iron County, August 28, 1913, *Pennell 5322* (Penn).

OKLAHOMA: rocky creek, Tom Hale Camp, Latimer County, August 24, 1937, *Osborn 2163* (Mont).

TEXAS: ravines in pine hills, Bastrop, April 1928, *Duval* (Texas); Freestone County, October 1879, *Joor* (Louisiana); Freestone County, July 2, 1924, *Tharp 2908* (Texas).

34. **Schmaltzia trilobata** (Nutt. ex. Torr. & Gray) Small, Fl. Southeast. U. S., pp. 728, 1334. 1903.

*Rhus trilobata* Nutt. ex Torr. & Gray, Fl. N. Am. **1**:219. 1838; Barkl., Ann. Mo. Bot. Gard. **24**:399. 1937.

CANADA: common on the declivity of hills, Kanary River, Oct. 1, 1802, *Lewis 57* (Am. Phil. Soc. Herb in PA); Assiniboia, Milk River, July 9, 1895, *Macoun 10075* (Cath).

UNITED STATES: Northwest Territory, *Necollet 109* (PA); Rocky Mountains, *Nuttall* (PA).

SOUTH DAKOTA: Castle Rock, June 7, 1912, *Carr 453* (USAgr); Custer Forest, alt. 3500 ft., July 2, 1924, *Sheuling* (Idaho); Porcupine Creek, *Wolliams* (Minn).

NEBRASKA: Halsey, Aug. 26, 1907, *Krantter* (Penn); canyon at base of Court House Rocks, Cheyenne County, August 1889, *Smith* (Penn).

KANSAS: 3 miles west of Hays, July 18, 1935, *Bondy 190* (MontSC); floodplain forest near Iola, Allen County, May 13, 1936, *Osborn 589R* (Mont); Syracuse, Hamilton County, el. 3500 ft., July 15, 1893, *Thompson 120* (Calif).

OKLAHOMA: sand dunes near Norman, Cleveland County, March 7, 1936, *Demaree 11857* and Wichita Mountains, near Cache, Comanche County, April 5, 1936, *11955* (Texas); 2 miles south of Ringwood, Major County, July 3, 1936, *Gruver 94* (Texas); floodplain savannah in relict prairie, 6 miles east of Alva, Woods County, *Osborn 2034*, south facing bluff opposite Turner Falls, Murray County, July 27, 1937, *2047*, north facing bluff, Platt National Park, Murray County, July 27, 1937, *2057*, edge of Lost Lake, Witchita National Park, Comanche County, July 28, 1937, *2063*, roadside clump in prairie near Elk City, Beckham County, Aug. 14, 1937, *2079*, shinnery pasture, sandy soil, near Arentt, Ellis County, August 14, 1937, *2087*, oak hickory near Pryor, Mayes County, April 29, 1936, *533A*, old hickory forest near Stillwater, Payne County, May 8, 1936, *572R*, sandy bank 7 miles east of Fairview, Major County, July 24, 1937, *1994*, road cut through stabilized sand dunes north of the Cimmaron River, 15 miles west of Hennessey, Blaine County, July 24, 1937, *2001*, sandy bank, 8 miles west of Hennessey, Blain County, July 24, 1937, *2003*, $gy_1$ hills, 3 miles south of Hitchcock, Blaine County, July 25, 1937, *2008*, and 10 miles north Moreland, Woodward County, August 15, 1937, *2102* (Mont); 30 miles east of Vice, June 17, 1936, *Wilkins 2488* (PA).

TEXAS: Comstock, May 24, 1911, *Blair* (Mich); *Buckley* (PA); Guadalupe Canyon, Guadalupe Mountains, alt. 5000-6000 ft., May 29 & June 4, 1912, *Chase 5934* (Mich); Blanco road 8 miles north of San Antonio, Bexar County, March 12, 1932, *Clare 536*, Scenic Loop, Bexar County, May 11, 1932, *864*, and Oct. 19, 1933 (Cath); on mesquite plains near the Walker Tank, Crosby County, June 28, 1925, *Erlanson 1197* (Mich); Grayson County, Oct. 28, 1933, *Gilchrist 41* (Texas); near Kerrville, Kerr County, April 25-30, 1894, *Heller 1658* (Mich, Minn, PA); 1849-51, *Lindheimer* (Cath); spring, Sumoner, Caldwell County, *McBryde* (Texas); San Antonio, April 24, 1910, *Mackensen* and Kerrville, May 1, 1910 (Mich); Upper Blue Creek Canyon, Chisos Mountains, Brewster County, alt. 1520 m., July 1, 1931, *Moore & Steyermark 3326* (Mich); Chisos Mountains, July 5, 1931, *Mueller 8066*

(Mich, Texas); Valley of the Trinity, Fort Worth, April 4 & June 2, 1913, *Ruth 357* (Minn); Henderson, Rusk County, 1929, *School 19* (Texas); Hoffman Ranch, San Antonio, Feb. 17, 1918, *Schulz* (Mich); Glass Mountains, Aug. 11, 1925, *Tharp*, Red River near Odell, August 20, 1926, *4463*, and Austin, March 10, 1933 (Texas); Knickerbocker Ranch, Dove Creek, Tom Green County, May 1880, *Tweedy 97* (US); Thuco Tanks, El Paso County, Nov. 11, 1931, *Whitehouse* (Texas).

MONTANA: near Malt, Yellowstone County, alt. 3000 ft., June 27, 1926, *Bell* (Mont); Bridge Canyon, Bozeman, July 20, 1898, *Blankinship*, Sweet Grass River, June 16, 1900, Great Falls, July 10, 1900, Arden July 15, 1900, Gallatin County, July 10, 1901, Big Timber, July 10, 1901, Crow Agency, July 14, 1901, Billings, July 7, 1902, Glendive, June 27, 1903, (MontSC), dry hillside, Bozeman, May 5, 1906, *667* (Mont); Bad Lands near Medora, July 17, 1891, *Bolley* (MontSC); near mouth of Shield's River, June 5, 1883, *Canby & Scribner 19*[a] (PA); at the foot of the south slope of Bridger Mountains, May 14, 1900, *Chestnut & Jones 111* (USAgr); Helena, Breadwater County, June 28, 1931, *Flint* (Mont); CutBank, August 14, 1907, *Griffith 8843* (USAgr); "Ho ăt to ô nuts, a smoking mixture used by the Cheyenne Indians," Bighorn Mountains, July 1921, *Grinnell 46* (USAgr); Pine Hills 13 miles east of Miles City, August 30, 1938, *Gunterman Gx17* (Mont); banks of the Madison above Emm's, Sept. 1901, *Henshall* (MontSC); rocky sandstone cliffs about 1 mile northwest of Fish Creek, Wheatland County, June 20, 1934, *Hitchcock 2351* (Mont); Bozeman, May 18, 1901, *Jones* (Mont); Bozeman, 1886, *Koch* (MontSC); dry rocky soils on hilltop, near Ekalaka, Carter County, June 18, 1936, *Lovisik 355* (Mont, MontSC); about 200 m. west of Giant Springs along the brink of a hill, Great Falls, June 17, 1936, *Marsh 149* (Mont); Gardiner River, July 18, 1902, *Mearns 1203* (Mich); Lewis & Clark County, *Muth* (MontSC); Bridger Canyon, May 7, 1916, *Osenbrug* (MontSC); roadside west of Billings, Yellowstone County, July 3, 1934, *Rose 304* (Mont); Livingston, May 10, 1901, *Scheuber* (Minn); dry rocky soil, Dawson County, July 16, 1937, *Twedt* (Mont); west slope of the Belt Mountains, July 25, 1895, *Wilcox* (MontSC); Great Falls, May 26 & June 24, 1892, *Williams 277* (MontSC); moderately abundant on a sandy bank, Custer Flats, Custer County, June 17, 1935, *Woolfolk* (Mont).

WYOMING: Little Missouri Butte, August 12, 1897, *Griffiths & Carter* (Mich); Pine Bluffs, May 15, 1897, *Nelson 2881* (MontSC); along stream near Lovell, Big Horn County, July 25, 1932, *Rollins 295* (WashSC).

COLORADO: Spring Canyon, May 3, 1891, — 1245 (Mont); Cimmarin, alt. 6900 ft., July 11, 1901, Baker (WashSC); Durango, July 20, 1898, *Baker, Earle & Tracy 525* (Cal, Mich); gulch west of Soldier Canyon, May 21, 1898, *Crandall 1249* (WashSC); Waldron, July 18, 1934, *Davis 437.W* (IdahoSB); bluffs along Clear Creek, Denver, August 7, 1910, *Eastwood 22* (Mich); south of Canon City, Fremont County, alt. 5600 ft., July 1, 1924, *Erlanson 1225* (MontSC); Garden of the Gods near Manitou, Sept. 18, 1899, *Holm* (Cath); Boulder, August 1924, *Hynes* (Texas); Glen Eyrie, July 1879, *Kite* (Penn); along San Miguel River, 2 miles west of Naturita, Montrose County, July 15, 1935, *Maguire & Pirnian 12851* (USAgr); east of Fort Garland, alt. 8200 ft., *McKelvey 4781* (Mich); DeBegne, Mesa County, May 27, 1910, *Osterhout 4291*, Wray, Yuma County, June 21, 1910, *4331*, Owl Canyon, Larimer County, August 25, 1910, *4377*, Delta, Delta County, May 20, 1911, *4498*, *4498B*, Paonia, Delta County, May 21, 1911, *4529*, Grand Junction, Mesa County, May 23, 1911, *4538*, Glenwood Springs, Garfield County, May 24, 1911, *4569*, *4572*, July 25, 1911, *4614*, and Boulder, Boulder County, August 8, 1911, *4641* (Mich); north slope of canyon, Norwood Hill, San Miguel County, alt. 7000 ft., August 10, 1912, *Walker 414* (WashSC); Boulder Canyon, Sept. 3, 1913, *Young* (Texas).

NEW MEXICO: 14 miles southwest of Clayton, Union County, Sept. 18, 1936, *Cogdell 136* (USAgr); Vaqueros, Jicarilla Ranger District, Carson Forest, Rio Arriba County, alt. 2100 m., August 14, 1924, *Eggleston 20571* (PA); Mesilla, alt. 3900 ft., June 21, 1897, *Wooton 48* (US).

IDAHO: City Creek, Pocatello, Bannock County, July 17, 1937, *Davis 367.37*, and Hagerman Valley, Gooding County, May 8, 1936, *22.36* (IdahoSB); grassy banks of

gulches above Pocatello, July 22, 1897, *Henderson 2980* (WashSC); Payette, May 22, 1911, *MacBride 868* (MontSC, WashSC); Twin Falls & Shoshone Falls, July 26, 1911, *Nelson & MacBride 1350* (Cath, Idaho, MontSC, WashSC).

UTAH: Mouth of Sevier Canyon, south of Elsinore, May 8, 1938, *Barkley 3062* and 15 miles east of St. George, May 10, 1938, *3199* (Mont); southern Utah, May 1937, *Hitchcock* (Mont); gravel, Marysvale, alt. 6000 ft., 1894, *Jones 3338* (WashSC); south slope of Logan Canyon, 5 miles from its mouth, Cache County, alt. 5300 ft., August 22, 1934, *Maguire & Richards 5204* (USAgr); Salt Lake City, July 12, 1902, *Pammel & Blackwood* (Texas); Wasatch Mountains, Ephriam, June 11, 1908, *Tidestrom 1117* and June 17, 1908, *1168* (Cath); near Flaming Gorge, Daggett County, alt. 5500 ft., May 30, 1932, *Williams 457* (Cath).

NEVADA: Willow Creek, Charleston Mountains, Clarke County, alt. 1800 m., Aug. 6, 1935, *Clokey* (Cath).

ARIZONA: Stone Cabin Canyon, alt. 6000 ft., June 8, 1909, *Blumer 2818* (Mich); Chase Creek, Clifton, May 1899, *Davidson 175* (Mich); Fort Apache, June 21-30, 1890, *Palmer 590* (Minn).

MEXICO:—CHIHUAHUA: Majalca, August 24, 1935, *LeSeur M205*, Santa Clara Cañon, Oct. 10, 1935, *M428*, and mountains west of Chihuahua, Oct. 10, 1935, *M431* (Texas). COAHUILA: San Ysidro, district of Guerrero, May 14, 1929, *Mexia 2529* and May 16, 1929, *2535* (Mich); Sierra del Carmen, Cañon de Sentenela on Hacienda Piedra Blanca, Municipio de Villa Acuña, July 8, 1936, *Wynd & Mueller 613* (Cath). NUEVO LEON: Chipique, Sept. 25, 1937, *Kenoyer 176* (F); Sierra Madre Mountains, near Monterrey, July 23, 1933, *C. H. & M. T. Mueller 96* (Texas), west side of the divide of the Sierra Madre Oriental 15 miles southwest of Galeana, alt. 8500 ft., May 14, 1934, *393* and Sierra Madre Oriental about the head of Santa Barbara Canyon, alt. 7500 ft., May 25, 1934, *573* (F, Texas).

34a. **Schmaltzia trilobata** var. **anisophylla** (Jeps.) Barkl., n. comb.

*Rhus trilobata* var. *anisophylla* Jeps., Man. Fl. Pl. Calif., p. 608. 1925; Barkl., Ann. Mo. Bot. Gard. **24**:411. 1937.

UNITED STATES:—UTAH: 17 miles southwest of St. George, May 12, 1938, *Barkley 3339* (Mont).

NEVADA: edge of field in Larrea belt, Wilson's Ranch, Clark County, alt. 1200 m., June 19, 1938, *Clokey 8014*, north slope in Juniper belt, Kyle Canyon, Clark County, alt. 1700 m., June 21, 1938, *8015*, hillside in Pinyon belt, Cold Creek, alt. 1850 m., July 9, 1938, *8016*, wash in Juniper belt on Harris Springs road, Charleston Mountains, Clark County, alt. 1800 m., June 10, 1940, *8627* and *8632* (Mont); Mica Springs, alt. 4000 ft., April 14, 1894, *Jones 5064m* (US).

ARIZONA: Hall's Ranch, Whitetail Canyon, Chiricahua Mountains, alt. 5000 ft., August 22, 1906, *Blumer 1320* (Minn); Cameron, alt. 5000 ft., June 8, 1922, *Hanson A170* (Penn); Kearns County, August 5, 1925, *Harshberger* (Penn); 5 miles south of Pine, Gila County, alt. 5000 ft., July 1, 1928, *Wolf* (Cath).

OREGON: Grant's Pass, May 27, 1884, *Howell* (Calif, US).

CALIFORNIA: south side of Mount Shasta, Seskiyou County, August 1-5, 1897, *Brown 595* (MontSC); Surprise Canyon, Panamint Mountains, Inyo County, alt. 5300 ft., June 12, 1930, *Ferris 7983* (Cath); lower slopes of New York Mountains near Ivanpah, San Bernardino County, alt. 4200 ft., April 21, 1932, *Ferris & Bacigalupi 8080* (Mont); Hot Springs, July 24, 1875, *Palmer 46* (US); sand banks along Lytte Creek, near San Bernardino, San Bernardino County, alt. 1200 ft., June 29, 1909, *Parish 7135* (Mich).

34b. **Schmaltzia trilobata** var. **arenaria** (Greene) Barkl., n. comb.

*Rhus trilobata* var. *arenaria* (Greene) Barkl., Ann. Mo. Bot. Gard. **24**:408. 1937. *Schmaltzia arenaria* Greene, Leafl. Bot. Obs. & Crit. **1**:130. 1905.

UNITED STATES:—OHIO: Scioto River, May 18, 1895, *Parker* (Cath).

INDIANA: High wooded bank of Eel River, .5 mile south of Liberty Mills, Wabash County, May 3, 1921, *Deam 33632* (PA), Gary, Lake County, Sept. 20, 1937, *58503, 58504, 58505, and 58506* (Mont); Clark, May 15, 1897, *Umbach* (US).

ILLINOIS: Port Bryon, May 28, 1897, *E. T. & S. A. Harper* (CalA); near Chicago, July 7, 1929, *Henry 38* (Penn).

34c. **Schamltzia trilobata** var. **pilosissima** (Engler in DC.) Barkl., n. comb.

*Rhus trilobata* var. *pilosissima* Engler in DC., Monogr. Phaner. **4**:386. 1883; Barkl., Ann. Mo. Bot. Gard. **24**:409. 1937.

UNITED STATES:—TEXAS: side of dry canyon, east of Guadalupe Peak, Guadalupe Mountains, alt. 7500-8000 ft., May 29-June 4, 1912, *Chase 5959* (Mich); Austin, Sept. 2, 1918, *Tharp* (Texas); El Paso, 1932, *Whitehouse* (Texas).

COLORADO: Rule Creek, Bent County, June 9, 1910, *Osterhout 4305* (Mich); Soldiers Home Canyon, April 1899, *Phillips* (Penn).

NEW MEXICO: San Andreas Mountains, June 22, 1929, *Ellison 740* (CalLA); dry hills, Burro Mountains, July 1880, *Rusby 71* (Mich, Penn), and along Gila River, May 1887, (Mich); ridge above Little Dog Canyon, south side canyon below forks, at foot of low cliff, Eddy County, April 26, 1932, *Wilkens 1617*, Guadalupe Mountains, Otero County, May 4, 1932, *1780-A*, and Malpais lava flow northwest of Carrizozo, Lincoln County, June 12, 1932, *2412-B* (PA); Organ Mountains, alt. 4800 ft., Sept. 1, 1897, *Wooton 584* (US) and Dona Ana County, alt. 6000 ft., April 15, 1899 (MontSC).

ARIZONA: Hall's Ranch, Whitetail Canyon, Chiracahua Mountains, *Blumer 1319* (Ariz), Cañon de los Alisos, Pajarito Mountains, alt. 3500 ft., April 20, 1909, *2744*, and alt. 3000 ft., *2886* (Mich); Chiricahua Mountains, May 1, 1902, *Kellogg* (Ariz); Parker Creek, Tonto Forest, alt. 5100 ft., Oct. 14, 1936, *Little 4288* (Mont); foothills of Four Peaks, Mazatzal Range, March 11, 1929, *McKelvey 880* (Mich); Santa Rita Mountains, near Rozemont, May 8, 1902, *Thornber 2689* (Ariz).

CALIFORNIA: South of Newville, Glenn County, May 26, 1914, *Heller 11429* (Minn); Bootjack, Mariposa County, Oct. 11, 1931, *Howell 8137* (CA); near San Bernardino, April 16, 1916, *Parish 10774* (Minn).

34d. **Schmaltzia trilobata** var. **quinata** (Jeps.) Barkl., n. comb.

*Rhus trilobata* var. *quinata* Jeps., Erythrea **1**:141. 1893; Barkl., Ann. Mo. Bot. Gard. **24**:413. 1937.

UNITED STATES:—OREGON: bank of Klamath Lake, Clamath County, 1902, *Cusick* (WashSC).

CALIFORNIA: Canyon of Big Chico Creek, Butte County, March 19, 1914, *Heller 11212* (Minn); Humboldt County, July 23, 1888, *Hy-lim-Vum* (Calif); Weldon Canyon, Vaca Mountains, Sept. 13, 1891, *Jepson*, Miller Canyon, Solano County, Sept. 21, 1891, and Middleton Grade, Lake County, May 5, 1893 (Mich); mouth of San Jacinto Canyon, alt. 3000 ft., April 3, 1918, *Parish* (Cath); canyon and adjacent slopes, about 18 miles east of Ensenada on road to Ojos Negros, Sept. 14, 1929, *Wiggins & Gillespie 4052* (Mich).

34e. **Schmaltzia trilobata** var. **racemulosa** (Greene) Barkl., n. comb.

*Rhus trilobata* var. *racemulosa* Barkl., Ann. Mo. Bot. Gard. **24**:409. 1937.
*Schmaltiza racemulosa* Greene, Leafl. Bot. Obs. & Crit. **1**:142. 1905.

UNITED STATES:—ARIZONA: Bonita Canyon, Chiricahua Mountains, Nov. 2, 1906, *Blumer 1321* (Ariz, Mich), lower trail of the Rincon Mountains, *3490* (Ariz), and Mexican Boundary Monument 127, Pajarito Mountains, August 5, 1910, *3770* (Mich).

34f. **Schmaltzia trilobata** var. **serotina** (Greene) Barkl., n. comb.

*Rhus trilobata* var. *serotina* Barkl., Ann. Mo. Bot. Gard. **24**:406. 1937.

*Rhus aromatica* var. *serotina* Rehder, Journ. Arn. Arbor. **20**:415. 1939.
*Schmaltzia serotina* Greene, Leafl. Bot. Obs. & Crit. **1**:141. 1905.

This variety is somewhat intermediate between typical *S. crenata* and *S. trilobata*, having larger and thinner leaves than the latter. However, since the habit, long pedicellate flowers, time of appearance of the flowers, and the fruit characters are similar to those of *S. trilobata* it seems best to regard it as a variety of that species.

UNITED STATES:—MISSOURI: Swope Park, Kansas City, June 14, 1937, *Barkley* (Mont); Swope Park, June 9, 1924, *Bush 10244* and *10244A*, June 20, 1924, *10259* (Cath), and Lanes' Prairie, May 10, 1934, *13492* (Penn); Irontown, May 4, 1932, *Epling 5957* (CalLA); Jerome, May 14, 1913, *Kellogg 380* (Texas); North Fork of the Spring River, Jasper County, May 14, 1906, *Palmer 30127* (Cal); 6 miles south of Conway, Webster County, June 19, 1932, *Wilkens 2533* (PA).

ARKANSAS: Pope Creek, Montgomery County, May 1, 1927, *Ashe* (Cath); edge of limestone cliff near the Illinois River, Washington County, April 23, 1935, *Fassett 17546* (WashSC).

NEBRASKA: Franklin, July 4, 1930, *Hapeman* (Cath, WashSC).

KANSAS: College pasture, 3 miles west of Hays, Ellis County, July 10, 1935, *Bondy 190* (USAgr); old woodlot, 15.5 miles north and one west of Ottawa, Douglas County, May 20, 1936, *Osborn 726R* and draw in meadow near West Mankato, Jewel County, June 2, 1936, *955R* (Mont).

OKLAHOMA: 1 mile south of Perkins, Payne County, May 1, 1937, *Davies 94* (Texas); savannah, near Duncan, Stephens County, April 10, 1936, *Osborn 379R*, sandy oak Savannah, near Chickasha, Grady County, April 22, 1936, *469R*, sagebrush near Weiling, Woodward County, April 23, 1936, *481R*, and sandy bank 8 miles west of Hennessey, Blaine County, July 24, 1937, *2004* (Mont).

34g. **Schmaltzia trilobata** var. **simplicifolia** (Greene) Barkl., n. comb.

*Rhus trilobata* var. *simplicifolia* Barkl., Ann. Mo. Bot. Gard. **24**:410. 1937.
*Rhus canadensis* var. *simplicifolia* Greene, Bull. Torr. Bot. Club **17**:13. 1890.

UNITED STATES:—COLORADO: Bedrock, western Montrose County, alt. 5000 ft., *E. B. & L. B. Payson 3932* (MontSC).

UTAH: Monument Valley, San Juan County, Sept. 14, 1939, *Eastwood & Howell 6678* (CA); Kanab, alt. 5500 ft., May 22, 1894, *Jones 5286e* (US); Zion Canyon in Zion National Park, Washington County, alt. 4000-5000 ft., May 7, 1934, *McKelvey 5225* (Mich).

ARIZONA: Diamond Valley, May 16, 1902, *Goodding 832* (US); Grand Canyon of the Colorado, Oct. 21-26, 1906, *Hohlshy* (PA); Navaho Reservation, July 1916, *Vorhies 114* (Calif).

MEXICO: San Matias Pass, San Pedro Martin Mountains, June 28, 1905, *Goldman 1187* (Mich).

LIST OF EXSICCATAE

Adams, J. W. 4304 (33).
Adams, J. W., & E. T. Wherry 2444 (33).
Agnes, Sr. Rose ....., ..... (33).
Anderson, H. ..... (15).
Anderson, H. & Carl Epling ..... (15).
Anthony, A. W. 98 (13); 305 (10); 318A (13).
Ashe, W. W. ..... (22); ..... (33); ..... (34f)
Bailey, V. ..... (15).
Baker, C. F. ..... (34); 4156 (13).
Baker, C. F., F. S. Earle & S. M. Tracy 525 (34).
Ballington, Cecil ..... (33).
Barber, H. S. ..... (15).
Barlow, Bronson ..... (30).
Bartlett, H. H. 994 (33).
Barkley, Fred A. 3062, 3199 (34).
Barkley, Wm. W. ..... (34f).
Bartram, E. B. ..... (23).
Beasley, P. ..... (33).
Beckman, ..... (22).

Bell, E. J. ..... (34).
Benham, H. R. ..... (15).
Birkman, ..... (15) ; ..... (30).
Bink, ..... (30).
Blair, R. E. ..... (34) ; 217 (30).
Blankinship, J. W. ....., ....., ....., ....., ....., ....., ....., ....., ....., 667 (34).
Blomquist, H. L. 4130 (33).
Blumer, J. C. 1319 (34c) ; 1320 (34a) ; 1321 (34e) ; 1322 (30) ; 1323 (23) ; 1858 (30) ; 2744 (34c) ; 2818 (34) ; 2886 (34c) ; 2929 (30) ; 3490, 3770 (34e)
Bodeu, 132 (22).
Bolley, H. L. ..... (34).
Bondy, Earle 180 (34f) ; 190 (34).
Brainard, Ezra ....., ..... (33).
Bandegee, T. S. 818 (13).
Braunton, Ernest 1026 (15).
Brown, C. A. 5340 (33).
Brown, H. E. 595 (34a).
Bray, W. L. ....., 408 (30).
Brinkerhoff, ..... (15).
Buckley, S. B. ..... (34).
Bush, B. F. 10244, 10244a, 10259 (34f) ; 12117, 12805 (33) ; 13492 (34f).
Camp, W. H. 2315 (21) ; 2321 (24) ; 2706-I (27) ; 2706-II (24).
Canby, Wm. M. & F. Lawson Scribner 192 (34).
Carter, W. T. ..... (30).
Cassidy, J. & Taylor ..... (30).
Chadwick, F. H. ..... (15).
Chase, Agnes 5921, 5924, 5933 (30) ; ....., ....., 5934 (34) ; 5959 (34c) ; 6033 (30).
Chestnut, Y. K. & A. W. Jones 111 (34).
Clare, Sr. Mary 95 (30) ; 381 (22) ; 536 (34).
Clements, F. E. & E. S. 188 (13).
Cleveland, D. ..... (13).
Clokey, I. W. ..... (34) ; 4994 (T3) ; 8014, 8015, 8016, 8627, 8632, (34a).
Clokey, I. W. & B. Templeton 4431 (15) ; 4605 (13).
Cocks, R. S. ..... (33).
Cogdel, R. R. 136 (34).
Collom, Rose. E. 297 (15).
Craig, Moses ..... (33).
Craig, T. 314 (13).
Crandall, C. S. 1249 (34).
Cusick, W. C. ..... (34d).
Davidson, A. 175 (34) ; 177 (30) ; 2506 (13).
Davies, F. 94 (34f).
Davis, John ....., 2646 (33).
Davis, Raymond J. 22.36, 367.37, 437W (34).
Deam, Chas. C. ....., 16064, 17833, 17901 (33) ; 33632, 58503, 58504, 58505, 58506 (34b) ; 58325 (33).
Dean, Walter ..... (33).
Demaree, Delzie 11857, 11955 (34).
Dodge, C. K. ....., 2350 (33).
Dunn, G. W. ..... (13).
Duran, Victor 3498 (15).
Durand, E. G. ..... (33).
Duval, H. H. ..... (33).
Eastwood, Alice 22 (34) ; 8102, 17777 (23).
Eastwood, Alice & John Thomas Howell 6678 (34g).
Edwards, M. T. 779 (18).
Eggleston, W. W. 10647 (23) ; 16689 (30) ; 20571 (34).
Elliston, L. 740 (34e).
Elmer, A. D. E. 3898 (13).
Epling, Carl. ..... (15) ; 5957 (34f) ; 6462 (13).
Epling, C. N. Dunn & A. Geon ..... (15).
Epling, C. and Lincoln Ellison ..... (13) ; ..... (15).
Epling, C. & Wm. Stewart ..... (13).
Epling, M. & C. ..... (13).
Erlanson, C. O. 1197, 1225 (34).
Evermann, B. W. ....., ..... (13).
Eyster, Wm. H. ..... (33).
Fassett, N. C. 17546 (34f).
Fauntleroy, ..... (13).
Ferris, Roxana S. 7983 (34a).
Ferris, Roxana S. & Rimo Bacigalupi 8080 (34a).
Ferris, Roxana S. & Carl D. Duncan 2343 (30).
Fisher, G. T. ..... (33) ; 37209 (18).
Flint, Howard R. ..... (34).
Fogg, J. M., Jr. 13019, 13346, 14705, 14869, 14963 (33).
Fosberg, F. R. S3813 (23) ; S4286, 7625 (13) ; 8150, 8160 (15).
Freeman, O. M. ..... (33).
Fröderström, H. & E. Hulten ....., 961 (9).
Gentry, H. S. 1746 (26) ; 3671 (31).
Gilchrist, C. 41 (34).
Goldman, E. A. 1187 (34g).
Goodding, L. N. 719 (15) ; 813 (23) ; 832 (34g).
Goodman, G. J. & C. L. Hitchcock 1146 (30).
Grant, G. B. 1118, 1120 (13).
Greene, Edward L. ..... (15).
Griffiths, D. 8843 (34).
Griffiths, D. &. L. W. Carter ..... (34)
Grinnell, G. B. 46, (34).
Gruver, D. 94 (34).
Gunterman Gx17 (34).
von Hagen, C. & von Hagen 1149 (9).
Hanson, Herbert C. A170 (34a) ; 393 (30).
Harper, E. T. & S. A. ..... (34b).
Harris, J. Arthur C22807 (13).
Harshberger, J. W. ..... (33) ; ..... (34a).
Hartman, C. V. 79 (30).
Hasse, H. E. ....., ..... (13).
Havard, V. ..... (24).
Heller, Arthur A 1658 (34) ; 11212 (34d) ; 11429 (34e).
Henshall, Mrs. H. F. ..... (34).
Henderson, Louis F. 2980 (34).
Henry, H. K. 38, (34b).
Hitchcock, C. Leo. 2351 (34).
Hilend, Martha 673 (30) ; 786 (23).
Hilend, M. & K. Kinsel ..... (13).
Hill, R. R. 413 (15).
Hockenderfer, Mr. and Mrs. ..... (15).
Hohlshy, ..... (34g).
Holm, Th. ....., ..... (33) ; ..... (34).
Hosfort, F. ..... (33).
Howarth, Wright ..... (33).
Howell, John Thomas ..... (34a), 2870, 3813 (13) ; 8137 (34e).
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# Pseudosmodingium and Mosquitoxylum

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The present paper is a continuation of the studies in the Anacardiaceae begun by the senior author,* and completes the treatment of the biological entity which composes the Rhus-complex for North America. *Mosquitoxylum* and *Pseudosmodingium* are Central American plants which are closely related to the genera which historically have been treated as *Rhus*.**

Bonpland, Humboldt, and Kunth described a plant from Mexico as *Rhus perniciosa* in 1821, but as questionably belonging to the genus *Rhus*. In 1876 D'H. Baillon published two new species which he assigned to the genus *Smodingium, S. Andrieuxii* and *S. Virletii*. While working with the Anacardiaceae, A. Engler, in 1881, segregated these three species to form a new genus, *Pseudosmodingium,* which differs principally from *Smodingium* in having the styles terminal and the ovule not suspended from the top of the ovary, and from *Rhus* in having the drupe reniform, strongly compressed and samara-like. The collections of Sessé & Mocino evidently contained mixed specimens of *P. perniciosum* and of another species, if one is to judge from the descriptions of De Candolle and of Sessé and Mocino. This mixture was described by De Candolle in 1825 as *Spathelia (?) rhoifolia* and by Sessé and Mocino in 1887 as *Rhus Pterocarpus*. The drawing in De Candolle's *Calques des Dessins . . .* is of *P. perniciosum,* but the specimen still extant in the Sessé & Mocino collection bearing the label *Rhus Pterocarpus,* is of another species, here treated as *P. rhoifolia*. In 1901 Rose published *P. multifolium,* which had been collected in Oaxaca, Mexico, by Mr. E. W. Nelson and Rev. Lucius C. Smith. There are comparatively few specimens of these species to be found in herbaria. *P. multifolium* and *P. perniciosum* have been collected more frequently than *P. rhoifolium, P. Virletii* and *P. Andrieuxii,* which are represented by single collections.

From J. H. Hart's specimens collected in Jamaica, Krug and Urban described the genus *Mosquitoxylum* in 1897, by the publication of *M. jamaicense*. Since that time collections have been made in Jamaica, and from Mexico to Panama. However, the specimens from the mainland proved to be different from those on the Island of Jamaica, and are here treated as a variety.

In common with the other genera closely related to *Rhus,* the two under consideration possess small, cyclic, heterochlamydic, and polygamo-dioecious, pentamerous flowers. The superior, tricarpellary pistil has a single fertile

* Barkley, Fred A. A Monographic Study of Rhus and Its Immediate Allies in North and Central America, including the West Indies. Ann. Mo. Bot. Gard. **24**:265-498. 1937.

** The Rhus-complex. Barkley, Fred A. *Ibid.*, pp. 266-282.

carpel containing a basally attached and anatropous ovule. Both have a disk between the pistil and stamens. The stamens are as many as the petals and alternate with them. The calyx in fruit is not enlarged. The petals are truncate. An insight into the general morphological relationship between these and the closely related genera of the Anacardiaceae may be gained by reference to the key to the genera of the Rhus-complex of the New World given on page 672.

All the species of *Pseudosmodingium* are limited, as far as recorded, to southern Mexico; *Mosquitoxylum* being more widespread occurs in Jamaica and from Mexico to Panama.

The members of both genera are medium-sized trees whose branches are typically thick. Schizo-lysigenous canals are present in the phloem; the effluvium from which soon hardens and blackens on exposure to air. *Pseudosmodingium* is reported as containing an irritant poison effecting most people to a greater or lesser degree much as the effluvium of *Toxicodendron*.

The leaves are always alternate and imparipinnately many-folioliate. There is a slight diversity in the leaflet outline of some of the species particularly in regard to the apices. In texture the laminae vary from thin-coriaceous to subcoriaceous. In *Mosquitoxylum* the upper surfaces are more or less lustrous and the margins of the leaflets are conspicuously inrolled; while in *Pseudosmodingium* the surfaces are typically pruinose and the margins are flat. In both, the under surfaces of the leaflets are usually duller and lighter in color than the upper surfaces. The rachis segments are wingless. In *Pseudosmodingium* the veins and leaflet margins are whitened.

*Mosquitoxylum* has simple unbranched trichomes on the stems, leaves, and inflorescences. All species of *Pseudosmodingium* appear glabrous, but one species has a minute puberulence on the under surface of the leaflets and other species have a sparse glandular pubescence.

The inflorescence of *Pseudosmodingium* is an erect panicle with a stout rachis and slender pedicels; of *Mosquitoxylum* a stout compound spike similar to that of *Schmaltzia*. The bracts of both genera are deltoid. Those of *Pseudosmodingium* are caducous, a single bract subtending each flower. In *Mosquitoxylum* a persistent bract and two persistent bractoles subtend each flower, as is found in *Schmaltzia*.

The calyces are five-parted, composed of five sepals which join at the disk. The sepals vary from deltoid to ovate. The corollas consist of five caducous petals which are usually broadly lanceolate in shape. The disks are broad and saucer-shaped.

The stamens are borne under the edge of the disk, alternating with its lobes and the petals. The filaments are usually long and thick and are surmounted by oblong-ovate anthers. The size of the anthers vary greatly in the same species depending on the degree of sexuality.

The stigmas are separate and the styles are united near the base. The styles are attached at the apex of the tricarpellary ovary, which has but a single fertile carpel.

The fruit of *Mosquitoxylum* is a flattened dryish drupe, scarlet in color, in which the seed coats are permanently united. That of *Pseudosmodingium* is a much flattened, straw-colored to brown, dryish drupe with the margins extended into wings simulating a samara. Both genera have glabrous shining fruit.

There is a single anatropous ovule in the one fertile cell of the ovary. The seed of *Mosquitoxylum* is about 6 mm. long, 7 mm. broad, and 2.5 mm. thick; of *Pseudosmodingium* approximately 3 mm. long, 5 mm. broad, and 1 mm. thick. In both genera the seed coat is thin, hard, and bony. The seed of *Mosquitoxylum* is flattened, smooth and lenticular in cross-section; in *Pseudosmodingium* it is reniform, roughened and oblong-ovate in cross-section.

The species involved in this study are, in each case, well differentiated. There is little variation among the specimens of a species except in size. However, there is a distinctive variation in the shape of the leaflets of *P. perniciosum*.

The relationship of the two genera is somewhat obscure; however, the relationship of *Pseudosmodingium* with *Rhus* would be obvious if one disregarded the fruit. The compound spikes, and the bract and bracteoles, of *Mosquitoxylum* are very similar to those of *Schmaltzia*, while the poison qualities and the fruit contrast sharply. There is at present no paleobotanical evidence to show the phylogeny of these genera.

They are of little economic importance. The wood of both is used locally for various purposes.

The completion of this study was made possible through the assistance of various groups and individuals to whom the authors wish to extend their thanks:

The American Philosophical Society's Penrose Fund which has made the collection of literature possible and has assisted in the assemblage and photographing of herbarium specimens; the directors and curators of the Paris Museum and of the Field Museum for the photographs of the types of *P.*

PLATE 1: Flower structure of *Pseudosmodingium*, ×12 (except fig. 17, ×40). Figs. 1-8, *P. rhoifolium* (DC.) Barkl., figs. 9-20, *P. multifolium* Rose, figs. 21-29, *P. perniciosum* (HBK) Engl. 1, Longitudinal section through a staminate flower. 2, Bract subtending a flower. 3, Lateral view of staminate flower. 4, Stamen of a staminate flower. 5, Pistil of a staminate flower. 6, Sepal of a staminate flower. 7, Petal of a staminate flower. 8, Disk of a staminate flower. (From *Sessé, Mocino et al. 4938.*) 9, Longitudinal section through staminate flower. 10, Pistil of staminate flower. 11, Portion of an inflorescence showing a bract. 12, Lateral view of a staminate flower. 13, Sepal of a staminate flower. 14, Stamen of staminate flower. 15, Stamen of a pistillate flower. 16, Pistil of a pistillate flower. 17, Trichome from a bract. 18, Petal of a staminate flower. 19, Disk of a staminate flower. (Pistillate from *Conzatti 1799*, staminate from *Purpus 3168*). 20, Disk from pistillate flower. 21, Longitudinal section through pistillate flower. 22, Portion of inflorescence showing bract. 23, Face view of staminate flower. 24, Sepal of staminate flower. 25, Petal of pistillate flower. 26, Stamen of a pistillate flower. 27, Stamen of a staminate flower. 28, Pistil of a staminate flower. (Pistillate from *Hinton 7034*, staminate from *Hinton 6946.*)

PLATE 1

*Virlettii* and *P. Andrieuxii;* Dr. J. W. Severy for the use of laboratory facilities of Montana State University where much of the research was pursued.

For the use of specimens the authors are indebted to the directors and curators where they have studied material or from which material has been borrowed.

The herbaria from which material has been studied and from which specimens are cited are indicated by the following abbreviations:

Berlin—Botanischer Garten und Botanisches Museum, Berlin-Dahlem.
Calif.—University of California Herbarium, Berkeley.
Cathol.—Catholic University of America, Washington.

Fig. 1. The known geographic distribution of *Pseudosmodingium.*

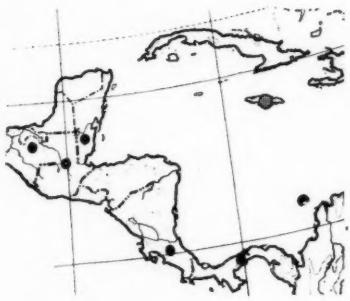
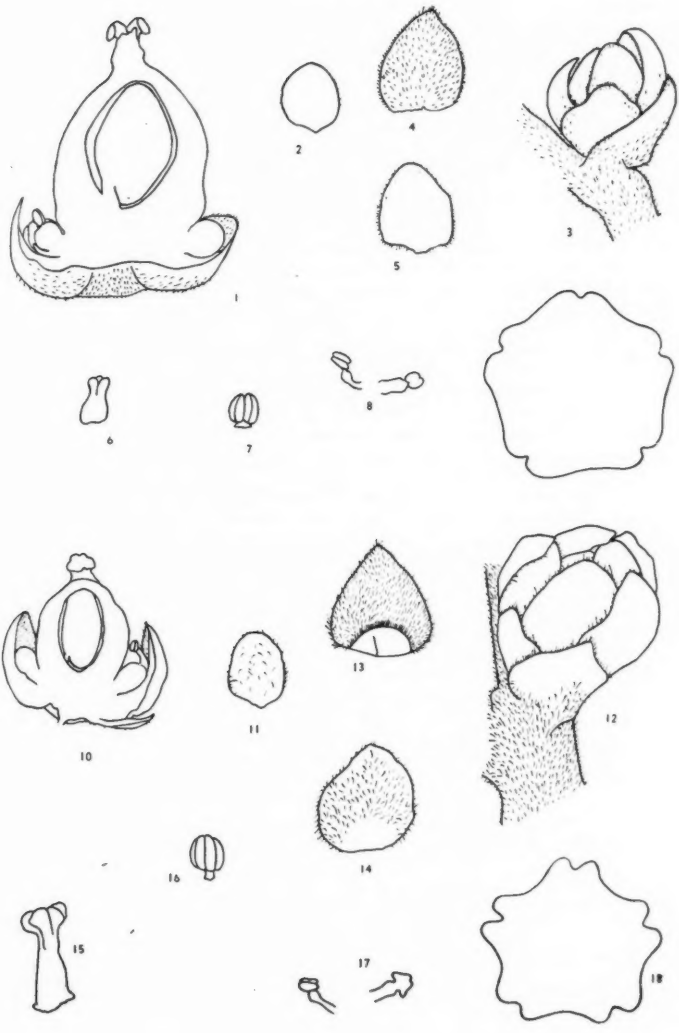



Fig. 2. The known geographic distribution of *Mosquitoxylum.*

PLATE 2: Flower structure of *Mosquitoxylum,* ×17. Figs. 1-9, *M. Jamaicense* Krug et Urban, figs. 10-18, *M. jamaicense* Krug et Urban var. *panamense* Barkley and Reed. 1, Longitudinal section through a pistillate flower, showing the developing ovary. The petals are caducous; the sepals persistent. 2, Inside of a bract. 3, Lateral view of pistillate flower. 4, Petal of a pistillate flower. 5, Sepal of pistillate flower. 6, Pistil of a staminate flower. 7, Stamen of a staminate flower. 8, Stamen of a pistillate flower, lateral and face views. 9, Outline of disk of pistillate flower. (Pistillate from *Hart 1287,* staminate from *Harris 9173.*) 10, Longitudinal section through a pistillate flower. 11, Inside of a bract. 12, Lateral view of a flower. 13, Petal of a pistillate flower. 14, Sepal of a pistillate flower. 15 Pistil of a staminate flower. 16, stamen of a staminate flower. 17, Stamen of a pistillate flower, lateral and face views. 18, Outline of disk of a pistillate flower. (Pistillate from *Lundell 118,* staminate from *Brenes 6272.*)

PLATE 2



Field—Field Museum of Natural History Herbarium, Chicago.
Gray—Gray Herbarium of Harvard University, Cambridge.
Kew—Herbarium of the Royal Botanical Gardens, Kew.
Mich.—University of Michigan Herbarium, Ann Arbor.
Minn.—University of Minnesota Herbarium, Minneapolis.
Mo.—Missouri Botanical Garden Herbarium, St. Louis.
Mont.—Montana State University Herbarium, Missoula.
ND—Greene Herbarium, University of Notre Dame, Notre Dame.
NY—New York Botanical Garden Herbarium, New York.
Paris—Herbiers du Museum National d'Histoire Naturelle, Paris.
Phil.—Academy of Natural Sciences Herbarium, Philadelphia.
U.S.—United States National Herbarium, Washington.

## Key to the Genera of the Rhus-Complex of the New World

Style lateral; leaves simple; pedicels of the sterile flowers at length becoming plumose; drupe becoming gibbous ..... *Cotinus*

Style terminal; leaves usually compound, pedicels of the sterile flowers never becoming plumose; drupe almost symmetrical.

Layers of the fruit wall not finally separating.

Style short and undivided; putamen smooth and chartaceous; effluvium poisonous ..... *Metopium*

Style longer and separate above; putamen smooth and bony; effluvium not poisonous ..... *Mosquitoxylum*

Layers of the fruit wall at length becoming more or less separate.

Drupe reniform, strongly compressed, samara-like; leaves imparipinnate; effluvium poisonous ..... *Pseudosmodingium*

Drupe globose, ovoid or slightly reniform and often somewhat compressed (but never so compressed as to appear winged); leaves simple, ternate or imparipinnate.

Ovary upon a gynophore formed by the disk; epicarp clothed with filiform silky hairs over 3 mm. long ..... *Actinocheita*

Ovary not on a column; epicarp when clothed with hairs, hairs less than 1.5 mm. long.

Drupes red, noticeably pubescent with red, glandular hairs; mesocarp not waxy.

Flowers in dense terminal thyrsi, appearing after the leaves; bracts linear-lanceolate, deciduous, one subtending each flower; bracteoles absent; branches thick ..... *Rhus*

Flowers in terminal and lateral compound spikes appearing with or before the leaves; bracts deltoid to ovate, persistent, one bract and two bracteoles subtending each flower; branches thin ..... *Schmaltzia**

Drupes white or dun colored; glabrous or sparingly pubescent, pubescence on the fruit never glandular; mesocarp waxy.

Sterile carpels forming a line down the side of the fruit; drupes very small; mesocarp without fibers; leaves coriaceous, simple; inflorescence a terminal thyrsus; innocuous evergreen shrub ..... *Malosma*

Sterile carpels not detectable at maturity; drupes over 2.2 mm. in diameter; mesocarp with "fibers"; leaves thin, compound; inflorescence a lateral panicle; poisonous, deciduous, small trees, shrubs, or vines ..... *Toxicodendron*

* **Schmaltzia** Desv. emend. Barkl. & Reed=Subgenus Schmalzia Desv. emend. Barkl., Ann. Bot. Gard. **24**:341. 1937.

## Taxonomy

### PSEUDOSMODINGIUM

*Pseudosmodingium* Engl., Bot. Jahrb. **1**:419. 1881; Engl. in Engler u. Prantl, Die Natürlichen Pflanzenfamilien **35**:167. 1896; Standley, (Trees and Shrubs of Mexico,) Contr. U. S. Nat. Herb. **23**:664. 1923.

Deciduous trees with thickened, dark-colored branches which are covered with tuberculate leaf scars; bark papery, reddish brown. Leaves alternate, imparipinnate, more or less persistent, clustered near the apices of the branches; leaflets several to many, glabrous to sparsely pubescent, subcariaceous; rachis not winged. Inflorescence an erect panicle bearing many, slender-pedicelled flowers, panicles clustered near the apex of the branch from buds produced in the axils of the previous years leaves, appearing with the leaves. Bracts of the inflorescence deltoid-lanceolate, deciduous. Flowers polygamo-dioecious. Petals and sepals 5, glabrous; sepals erect; petals spreading. Ovary 1-celled, at the center of the disk; style 3-branched, terminal; ovary winged. Stamens with filaments longer than the anthers, anthers rotund. Drupe flattened into two broad wings, glabrous, straw-colored to brown.

Southern Mexico.

Type species: *Pseudosmodingium perniciosum* (HBK) Engl., Bot. Jahrb. 1:419. 1881.

#### KEY TO THE SPECIES OF PSEUDOSMODINGIUM

Leaflets lanceolate or linear-lanceolate, 3-10 mm. wide.
- Leaflets about 7 pairs ..... 1. *P. Andrieuxii*
- Leaflets about 13 pairs ..... 2. *P. multifolium*

Leaflets oblong to broadly ovate, 1.5-4.5 cm. wide.
- Leaflets on petiolules 1-2.5 cm. long ..... 3. *P. perniciosum*
- Leaflets sessile or subsessile.
  - Leaflets oblong, base unequal, cuneate, decurrent on the petiolule.... 4. P. Virletii
  - Leaflets broadly oblong-ovate, base equal, truncate, not decurrent on the short petiolule ..... 5. *P. rhoifolum*

1. *Pseudosmodingium Andrieuxii* Engl., Bot. Jahrb. 1:420. 1881

Tree; leaves with about 13 leaflets, about 1.5 cm. between leaflets, rachis slender; leaflets lanceolate, about 3 cm. long, .8 cm. broad, subcoriaceous, glabrous except for a sparse puberulence on the larger veins below, apex acute to acuminate, base cuneate, margins serrate, sessile; panicle about 10 cm. long, 3 cm. broad, pedicels about 3 mm. long, slender; sepals slightly imbricated; drupe broadly winged, about 6 mm. long, 10 mm. broad, glabrous, straw-colored.

MEXICO: 1834, *Andrieux 184* (Field [fragment], Mont [fragment], Paris type, Kew).

2. *Pseudosmodingium multifolium* Rose, Contr. U. S. Nat. Herb. 5:143. 1905

Tree; leaves about 27-foliolate, 15-20 cm. long, about 1 cm. between leaflets, rachis slender; leaflets lanceolate, 1.5-2.5 cm. long, 3-6 mm. broad, darker above, subcoriaceous, sparse, minute glandular-pubescent above, glabrous

below, margins thickened, serrate, apex acute, base unequal and cuneate, sessile; panicle 4-8 cm. long, about 3 cm. broad, pedicels slender, about 5 mm. long; sepals ovate, 1.25 mm. long, 1 mm. broad, glabrous; petals whitish, ovate, 3 mm. long, 1 mm. broad, glabrous; stamens shorter than the petals, filament 1.25 mm. long, anther rotund, 1 mm. long, .75 mm. broad; drupe broadly winged, .9 cm. long, 1.4 cm. broad, glabrous, straw-colored.

MEXICO: 1841-1843, *Liebmann* (Berlin).

HIDALGO: Ixmiquilpan, May 1905, *Purpus 1295* (Calif., Field, Gray, Mo., NY).

OAXACA: 1100 m. alt., Cuesta de Quiotepec, Distrido de Cencallan, April 22, 1919, *Conzatti* (US); Etla, March, *Conzatti & Conimo* (US); 6500 ft. alt., Cuesta de Ejutla, Nacaltepec, June 1, 1895, *Smith 495* (Gray); May 1842, *Liebman 14848* (Field); 6000 ft. alt., April 6, 1895, *Nelson 2542* (US Type, Gray); 1900 m. alt., Cerro del Tule, March 31, 1907, *Conzatti 1799* (Field); 1650 m. alt., El Fortin, March 14, 1898, *Conzatti & Gonzalez 669* (Gray, Mo. photo.).

PUEBLA: San Luis Tultitlanapa, May 1908, *Purpus* (Gray, NY); San Luis Tultitlanapa, June 1908, *Purpus 3168* (Berlin, Calif., Field, Gray, Mo., NY).

3. *Pseudosmodingium perniciosum* (HBK) Engl., Bot. Jahrb. 1:419. 1881

*Rhus periniciosa* H.B.K., Nov. Gen. et Sp. **7**:10. 1825.
*Rhus Pterocarpus* Sessé & Moc., Pl. Nov. Hisp., p. 47. 1888, in part.
*Spathelia (?) rhoifolia* DC., Prodr. **2**:84. 1825, in part; DC., in A. DC., Calq. Dess. Fl. Mex. Moc. & Sessé, p 3, *pl. 190*. 1874.

Tree; leaves 9-15 foliolate, 25-35 cm. long, about 4 cm. between leaflets, rachis coarse; leaflets obovate to rhombic-ovate, 3.5-7 cm. long, 2.5-5 cm. broad, usually glaucous, slightly darker above, subcoriaceous, veins and margins whitened, glabrous, margin entire, apex truncate to subacute, sometimes mucronate, base unequal, cuneate, and decurrent on the petiolule; lateral petiolules 1.5-2.5 cm. long, terminal petiolule 3.5-4.5 cm. long; petiolules, rachis, and petiole glabrous; panicles 15-35 cm. long, 7 cm. broad; sepals slightly imbricated, 1 mm. long, 1 mm. broad, glabrous; petals whitish, 2.25 mm. long, 1.25 mm. broad, glabrous; stamens shorter than the petals, filament .75 mm. long, anther rotund, .5 mm. long, .5 mm. broad; drupe broadly winged, .8 cm. long, 1 cm. broad, glabrous, brown.

MEXICO: *Ghiesbreght 340* (Field); *Haenke* (Berlin); May 24, 1897, *Haenke* (Berlin).

GUERRERO: Chirapitera, Coyuca, Oct. 26, 1936, *Hinton 6896* (Field); Pungarabato, Coyuca, Nov. 1, 1934, *Hinton 6930* (NY); Chacamerito, Coyuca, Nov. 8, 1934, *Hinton 6946* (Field, Gray, NY); 2400-4000 ft. alt., mountains above Iquala, Oct. 5, 1900, *Pringle 8385* (Berlin, Calif., Field, Gray, Mich., Minn., Mo., Mo photo, ND, NY, Phil, US).

MEXICO: Ocotepec, Temascaltepec, Nov. 24, 1934, *Hinton 7034* (Field, NY); Naranjo, Temascaltepec, Oct. 5, 1932, *Hinton 1993* (NY).

MICHOACAN: El Japilote, March 31, 1903, *Nelson 6976* (Gray, Mo photo, US); Jorullo, Dec. 1829, *Schiede* (Berlin).

MORELOS: near Cuernavaca, 1905, *Lemmon 194* (Berlin, Calif, Field, Gray, Mo.)

4. *Pseudosmodingium Virletii* Engl., Bot. Jahrb. 1:419. 1881

Tree; leaves with about 13 leaflets, about 2.2 cm. between leaflets, rachis heavy; leaflets oblong, about 4.5 cm. long, 2.2 cm. broad, subcoriaceous, veins and margins somewhat whitened, glaucous with glandular pubescence, apex truncate, emarginate, base markedly unequal, cuneate, decurrent to the rachis on the petiolule; lateral petiolules about 3 mm. long, terminal petiolule about 1.5 cm. long; petiolules, rachis and petiole glabrous (?); panicle about 20 cm. long, 7 cm. broad, petiolules about 3 mm. long, slender; sepals slightly imbricated; drupe broadly winged, 6 mm. long, 12 mm. broad, glabrous, brown.

MEXICO: 1850, *Virlet d'Aoust 1044* (Field [fragment], Mont [fragment], Paris type).

5. *Pseudosmodingium rhoifolium* (DC.) Barkl., Ann. Mo. Bot. Gard. 24:500. 1937

*Pseudosmodingium Pterocarpus* (Sessé & Moc.) Barkl., Ann. Mo. Bot. **24**:263. 1937.
*Rhus pterocarpa* DC., Prodr. **2**. 84. 1825, in syn., in part.
*Rhus Pterocarpus* Sessé & Moc., Pl. Nov. Hisp., p. 47. 1888, in part.
*Spathelia (?) rhoifolia* DC., Prodr. **2**:84. 1825, in part.

Tree; leaves 9 or more foliolate, about 3 cm. between leaflets, rachis coarse; leaflets broadly oblong-ovate to orbicular, about 4.5 cm. long, 3.5 cm. broad, glaucous, darker above, subcoriaceous, veins and margins whitened, very sparsely pubescent above, sparsely pubesecnt below, margin entire, apex truncate, often mucronate, base equal, truncate, barely decurrent on the petiolule if at all; lateral petiolules about 2.5 mm. long, terminal petiolule about 2 cm. long; petiolules and rachis sparsely pubescent; inflorescence about 13 cm. long, 3 cm. broad; sepals slightly imbricated, half-orbicular to rounded deltoid, 1 mm. long, .7 mm. broad, glabrous; petals ovate, 2.25 mm. long, 1.5 mm. broad, glabrous; stamens 5, filaments 1 mm. long, anthers rotund, .5 mm. long; drupe broadly winged, 6 mm. long, 8 mm. broad, glabrous, brown.

While the specimen of this plant in the Sessé & Mocino collection when compared with the descriptions of De Candolle and of Sessé & Mocino and with the drawing in A. DC.'s *Calques* . . . shows that the De Candolle and the Sessé & Mocino descriptions must have been drawn from a mixture of this species and *P. perniciosum*, this species is all that remains in the Sessé & Mocino collection (and labelled by them *R. Pterocarpus*), so it seems desirable to redefine it but retain the name for this very distinctive species.

MEXICO: 1787-1804, *Sessé, Mocino, Castillo, & Maldonado 4938* (Field [fragment of type], Mo photo).

## MOSQUITOXYLUM

*Mosquitaxylum* Krug et Urban, Notizbl. Bot. Gart. u. Mus. Berlin **1**:78. 1895; Urban, Symb. Antill. **1**:343. 1899. Engler u. Prantl, Die Natürlichen Pflanzenfamilien **3**5:459. 1896; *ibid.* Nachträge II-IV, p. 214, 1897; Standley, (Trees and Shrubs of Mexico,) Contr. U. S. Nat. Herb. **23**:664. 1923.

Tree. Leaves alternate, imparipinnate with 11-29 leaflets, more or less persistent. Leaflets subcoriaceous, subglabrous to pubescent above and below, margins subrevolute; rachis almost terete. Flowers polygamo-dioecious, in loose ascending compound spikes in the axils of the leaves. Calyx 5-lobed, persistent. Petals 5, ascending, almost glabrous. Ovary 1-celled, sessile on the disk; style 3-branched, terminal; stigmas 3. Drupes flattened, shining, scarlet; epicarp glabrous, shining; mesocarp thin; endocarp bony; fruit coats permanently united; seed flattened.

Jamaice and Central America.

Type species: *Mosquitoxylum jamaicense* Krug et Urban, Notizbl. Bot. Gart. u. Mus. Berlin 1:78. 1895.

KEY TO THE SPECIES AND VARIETY OF MOSQUITOXYLUM

Leaves not soft pubescent above; leaflets about 13; Jamaica.....1. *M. jamaicense*
Leaves soft pubescent above; leaflets about 19; Mexico to Panama .....
.....1a. *M. jamaicense* var. *panamense*

1. *Mosquitoxylum jamaicense* Krug et Urban, Notizbl. Bot. Gart. u. Mus. Berlin 1:78. 1895

Tree up to fifty feet tall; branches relatively thick with large pith; bark of branches olive gray, scurfy, sparsely puberulent, lenticels prominent; roughened by leaf scars at least near the tip; leaves imparipinnately compound, about 24 cm. long, clustered at the apices of the branches; leaflets about 13, oblong-oblanceolate, about 7.6 cm. long, 2.4 cm. broad, shining above, dull below, subcoriaceous, glabrous to sparsely puberulent, pubescence at maturity heavier on the veins, margins subrevolute, entire, apex subacute, base cuneate, unequal, petiolules of lateral leaflets short, about 5 mm. long, terminal leaflet petiolulate with petiolule about 15 mm. long, petiolules puberulent to subglabrous; rachis slender, about 15 cm. long, sparsely puberulent to subglabrous at maturity; petiole about 3.5 cm. long, relatively slender, sparsely puberulent to subglabrous at maturity, thicker at base; inflorescence a thrice compounded spike about 27 cm. long, 10 cm. broad, several inflorescences clustered at the apex of the stem; flowers many, sessile, each flower subtended by a deltoid bract and two deltoid bracteoles; bracts and bracteoles persistent, pubescent on both surfaces, ciliate with simple hairs, about .7 mm. long; sepals 5, ovate, 1 mm. long, strongly imbricated, slightly pubescent, ciliate with simple hairs, more or less persistent; petals 5, broadly ovate, about .9 mm. long, whitish, sparsely pubescent on the inner surface, ciliate with simple hairs; stamens with very short filaments, anther rotund; pistil with 3 short, thickened, partially united styles, styles persistent; ovary 1-celled; drupe flattened, .8 x .7 x .25 mm., glabrous, scarlet.

Occurring on the Island of Jamaica in the West Indies from about 1500 to 2000 feet elevation. The wood, known as "mosquito-wood," is valued for building purposes.

JAMAICA: Hillside, Beau Fort near Newmarket, Sept. 13-22, 1907, *Britton 1562*

(NY); 2000 ft. alt., Lapland, near Catadupa, Feb. 13, 1906, *Harris 9173* (Berlin, NY, US); 1750 ft. alt., Lapland, Dec. 2, 1906, *Harris 9185* (Berlin, Field, NY); alt. 1500 ft., near Darliston, Sept. 9, 1907, *Harris 9828* (Berlin, Field, NY); District of Hanover, 1886, *Hart 1287* (Berlin, Field, Cotypes); Westmoreland, July 7, 1891, *Mennell 5631* (Berlin).

1a. **Mosquitoxylum jamaicense** var. **panamense** var. nov.

Arbor usque ad 24 m. alta; foliis circiter 30 cm. longis; foliolis plerumque 19, anguste oblongo-oblanceolatis, circiter 7 cm. longis, 2.1 cm. latis; supra lucidis et sparse puberulis, infra molliter pubescentibus et hebis, subcoriaceis, marginibus revolutis; petiolulis, rachis segmentis et petiolis molliter pubescentibus; sepalis atque petalis intus pubescentibus; drupe .75 x .6 x .25 cm.—Type: *Pittier 4143* in forests, Loma de la Gloria, near Fató (Nombre de Dios), Aug. 1911, in Botanischer Garten und Museum, Berlin-Dahlem.

Tree to eighty feet tall; leaves about 30 cm. long; leaflets about 19, narrowly oblong-oblanceolate, about 7 cm. long, 2.1 cm. broad, shining and sparsely puberulent above, soft pubescent and dull below; subcoriaceous, margins revolute; petiolules, rachis segments, and petiole soft-pubescent; sepals pubescent on the inner surface; petals pubescent on the inner surface; drupe .75 x .6 x .25 cm.

Occurring from southern Mexico to Panama. The variety is very similar to the species in general appearance, but is much more pubescent and usually has narrower and more numerous leaflets.

MEXICO: Teotalcingo, Oct. 1842, *Liebmann 14841* (Field).—CHIAPAS: 3000-5000 ft. alt., along the road between Teneapa and Yajalon, Oct. 13, 1895, *Nelson 3296* (Gray).

CENTRAL AMERICA.—BRITISH HONDURAS: Oct. 10, 1926, *Winzerling V-8* (Field, US); San José, Nov. 1927, *Aitken 1* (Field, Phil); Sierra de Agua, Sept. 17, 1928, *Brown 28* (Field); Freshwater Creek, 1928, *Heyder & Kinloch 31* (Field); Freshwater Creek Reserve, August 25, 1928, *Kinloch 58* (Field); Honey Camp, Orange Walk, Nov. 1928, *Lundell 118* (Field, Mich); near Honey Camp, 1930, *Meyer 102* (Field); 1600 ft. alt., near Middlesex, Nov. 7, 1929, *Schipp 442* (Calif, Field, Gray, Mich, Mo, NY).

GUATAMALA: in Acahual La Loca, La Libertad, August 5, 1934, *Aguilar 318* (Cathol, Field, Mich, Mo, Mo photo, NY); Monte Chicbul, La Libertad, June 1, 1933, *Lundell 3543* (Field, Mich).

COSTA RICA: La Palma de San Ramon, *Brenes 5149* (Field); La Calera de San Ramon, Nov. 27, 1928, *Brenes 6438* (Field); Cirri Colorado La Palma de San Ramon, Oct. 7, 1928, *Brenes 6341* (Field); Cirri Blanco La Palma de San Ramon, August 26, 1928, *Brenes 6272* (Field).

PANAMA: Barro Colorado Island, 1933, *Aviles 23b* (Field); Barro Colorado Island, July 14, 1934, *Aviles 955* (Field); Barro Colorado Island, Gatun Lake, August 27, 1929, *Bangham 426* (Field); Gatun, Nov. 1859, *Hayes 217* (NY); Gatun Station, Nov. 1859, *Hayes 568* (NY); 10-104 m. alt., in forests, Loma de la Gloria, near Fató (Nombre de Dios), August 1911, *Pittier 4143* (Berlin Type, Gray, NY, US).

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PLATE 3. Left: *Pseudosmodingium Andrieuxii* (Baill.) Engl. The type specimen, *M. Andrieux 184*, 1834, Mexico, in the Herbiers du Muséum National d'Histoire Naturelle, Paris. Right: *Pseudosmodingium Virletii* (Baill.) Engl. The type specimen, *Virlet d'Aoust* 1044, 1850, Prov. de San Luis, Mexico, in the Herbiers du Muséum National d'Histoire Naturelle, Paris.

PLATE 3. Left: *Pseudosmodingium Andrieuxii* (Baill.) Engl. The type specimen, *M. Andrieux 184*, 1834, Mexico, in the Herbiers du Muséum National d'Histoire Naturelle, Paris. Right: *Pseudosmodingium Virletii* (Baill.) Engl. The type specimen, *Virlet d'Aoust* 1044, 1850, Prov. de San Luis, Mexico, in the Herbiers du Muséum National d'Histoire Naturelle, Paris.

PLATE 4: Fig. 1, *Pseudosmodingium perniciosum* (H.B.K.) Engl. (From the collection of *E. W. Nelson 6976*, March 31, 1903, at El Japilote, Michoacan, Mexico.) Fig. 2, *Pseudosmodingium multifolium* Rose. (From the collection of *C. Conzatti & V. Gonzalez 119*, March 14, 1898, alt. 1650 m., el Fortin, Oaxaca, Mexico.) Fig. 3, *Pseudosmodingium rhoifolium* (DC.) Barkl. (From the fragment of the type specimen, *Sessé, Mocino, Castillo, & Maldonado 4938*, 1787-1804, in the Field Museum of Natural History Herbarium.) Compare the leaves of *P. multifolium* with those of *P. Andrieuxii* (Pl. 3), and those of *P. perniciosum* and *P. rhoifolium*.

# Studies in the Anacardiaceae—V

Fred A. Barkley

Since a new edition of Standardized Plant Names is being prepared, it seems appropriate to publish the combination **Toxicodendron Delavayi** (Franchet) Barkley, comb. nov. (=*Rhus Delavayi* Franchet, Bull. Soc. Bot. France **33**:466. 1886.) for this well established species, even though the author has not completed his study of the Old World members of *Toxicodendron*.

*Rhus verniciflua* Stokes, antedates the similar name for the same species, *Rhus vernicifera* DC. The combination of the latter specific epithet in *Toxicodendron* was formerly made since its description was written in Latin and Article 38 of the International Rules with its note is rather ambiguous as to the strictness of application prior to 1908; however, since it seems customary to interpret this rule to validate publications in modern languages during that period, it seems best to propose the following combination:

**Toxicodendron verniciflua** (Stokes) Barkley, n. comb.

*Rhus verniciflua* Stokes, Bot. Mat. Med. **2**:164. 1892.
*R. vernicifera* DC., Prodr. **2**:68. 1825, non Salisb., Prodr. p. 169. 1769, nec Bouley, Fl. Plio. Env. Theziers p. 54. 1890.
*R. Vernix* Thunb., Fl. Jap. p. 121. 1878, non L., Sp. Pl. **1**:265. 1753.
*Toxicodendron vernicifera* E. A. & F. A. Barkl., Ann. Mo. Bot. Gard. **24**:263. 1937.

Prof. Rehder has called the author's attention to an omission in the citation of synonymy in *Toxicodendron* (Barkley, F. A. Ann. Mo. Bot. Gard. **24**:418. 1937). To "Engler in DC., Monogr. Phaner. **4**:376. 1883, sect. VENENATAE excl. *R. laurina*" should be added "sect. TRICHOCARPAE as to *R. trichocarpa*."

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# A Key to the North American Species of Lobelia (Sect. Hemipogon)

Rogers McVaugh

In Mexico, Central America, the West Indies and southern United States there are found about thirty-five species of the genus *Lobelia (Campanulaceae, Lobelioideae)* which are alike in having blue or purplish flowers, herbaceous and often delicate stems, and tiny ellipsoid seeds which are shining and highly polished or occasionally bearing faint longitudinal lines. The hypanthium never bears auricles at the base of the calyx-lobes, and the bracteoles of the pedicel are normally minute and basal, or wanting. Some of the species of this group are rarely collected, and few of them are adequately known. In addition, the delimitation of species is more difficult than in any other subdivision of the genus with which the writer is familiar. It therefore seems desirable to present a brief synopsis of the classification of the species in question.

The most recent original treatment of the whole genus *Lobelia* is that of Bentham & Hooker* (1876), in which the authors delimited 8 sections within the genus. The species which are to be discussed in the present paper, so far as they were known to the authors of the "Genera Plantarum," were included either in the section *Hemipogon* or in *Holopogon*. The two sections were said to be alike except that in the former the two smaller anthers only were penicillate at tip, while in the latter all the anthers were penicillate. *Hemipogon* included a total of about 100 species, in all the continents, while *Holopogon* was said to include 29 species, of which two (*L. fenestralis* Cav. and *L. Hartwegi* A.DC.) are North American.

The present writer feels that the characters emphasized by Bentham & Hooker are not wholly adequate ones upon which to base sections or subgenera in such a genus as *Lobelia*. As has been previously stated[1], the most valuable morphological characters in all the genera of the *Lobelioideae* are furnished by the seeds. Not until seed-characters are used in conjunction with other morphological features will a truly natural system be worked out for the *Campanulaceae*. At the present time it is impracticable to extend the following synopsis to all the species of the large genus *Lobelia*, but for the more than 90 species native to North America the genus may be divided into six rather sharply defined sections:

1. Seeds sharply trigonous; flowers light-blue or white, small; plants delicate, herbaceous; bracteoles of pedicel basal, foliaceous, resembling stipules ..... Section *Holopogon* Benth. & Hook.

(This section was narrowed by C. B. Clarke [Fl. Brit. Ind. 3:423. 1881] to include 5 Indian species with trigonous seeds and 2 with ellipsoid seeds, and it

* Gen. Pl. v. 2.

1 Rhodora **38**:245. 1936; Amer. Midl. Nat. **22**:521-550. 1939.

appears that the single North American species with trigonous seeds should be assigned to it.)

1. Seeds ellipsoid, ovoid or subglobose, never trigonous ..... 2
2. Seeds markedly roughened, the surface deeply foveate-reticulate; mostly herbs, with blue or purplish flowers, natives of eastern United States and Canada; one coarse-herbaceous, red-flowered species almost throughout temperate North America and extending into the tropics; one shrubby, red-flowered species in the Greater Antilles ..... Section *Eulobelia* Benth. & Hook.
2. Seeds smooth, lustrous, the surface highly polished and without marks of any kind, or with faint longitudinal striations, or with regularly and shallowly impressed pits ..... 3
3. Seeds ellipsoid, with faint longitudinal lines; plants somewhat shrubby; flowers red or yellow, long-pedicellate, with minute bracteoles about the middle of the pedicel; 3 species in the Mexican region ..... Section *Homochilus* A.DC.
3. Seeds smooth, pitted or faintly lined; flowers blue, purple or white or, if red, yellow or green the species West Indian, with the bracteoles of the pedicel evident, somewhat foliaceous, never basal ..... 4
4. Seeds ellipsoid or ovoid, smooth and polished or with faint longitudinal lines; herbs, often delicate; corolla blue, purplish or white, never red, yellow nor green; bracteoles of the pedicel basal, minute, or wanting ..... 5
5. Corolla not cleft dorsally except at base; three larger anthers not white-tufted; inflorescence usually corymbose or subcapitate, not pedunculate ..... Section *Palmerella* (A. Gray) comb. nov.*
5. Corolla cleft dorsally from the apex, or, if not so, all the anthers white-tufted and the inflorescence spicate, long-pedunculate ..... Section *Hemipogon* Benth. & Hook.
4. Seeds orbicular to oblong-ovoid, shallowly pitted with roundish pits (rarely appearing tuberculate or lined); coarse herbs or sub-shrubs, with red, reddish-brown or purplish-brown, yellow or green flowers, the corolla never blue; bracteoles of the pedicel evident, somewhat foliaceous, never basal ..... Section *Tylomium* (Presl) Benth. & Hook.

When delimited as outlined above, the sections are well marked geographically; *Holopogon* extends into the West Indies from northern South America, *Eulobelia* is concentrated in eastern continental North America, *Homochilus* centers in southern Mexico and northern Central America, *Tylomium* is confined to the West Indies. As will be brought out below in detail, the fifth section, *Hemipogon*, has its largest number of species in Mexico and Central America; it also extends into southern United States and the West Indies, and is represented in South America by about a dozen species. *Palmerella* is of somewhat dubious affinities, with a single species in the Californian region. There are in South America probably two sections of the genus which are not represented in North America.

The limits of some of the sections, as defined in the above key, are at variance with those proposed by the original authors of the sections. *Holopogon* is here understood to include only those species having trigonous seeds; *Eulobelia* includes a number of North American species assigned by Bentham & Hooker to *Hemipogon*, but does not include *L. sessilifolia* Lamb., of eastern Asia, which was originally placed in it; *Homochilus* is restricted by the present writer to include *Lobelia laxiflora* and two related species, the others mentioned

* Based on *Palmerella* A. Gray, Proc. Amer. Acad. **11**:80. 1876, as genus.

by DeCandolle being placed elsewhere; *Tylomium* is essentially as understood by Bentham & Hooker. The writer is not prepared to state with certainty that the remaining section, *Hemipogon*, is the largest in the genus, but it seems probable that such is the case, and that it should include many Old World species.

KEY TO THE NORTH AMERICAN SPECIES OF HEMIPOGON

1. Corolla-tube 7.0 mm. long (rarely 6.5 mm.) or more, measured from the base of the calyx-lobes to the deepest point of the lateral sinus of the corolla; filament-tube usually more than 5.0 mm. long ..... 2
2. Corolla-tube fenestrate laterally near base on both sides, the opening taking the form of a slit adjacent to and parallel with the dorsal slit (which may be wanting) in the corolla-tube ..... 3
3. Corolla cleft nearly to base on one side; filament-tube 5 to 7 mm. long..... ..... *L. Hartwegi*, p. 696
3. Corolla not cleft, the tube entire except for the lateral openings near base; filament-tube 11.0 to 12.5 mm. long ..... *L. sinaloae*, p. 696
2. Corolla-tube not fenestrate laterally, entire except for the dorsal fissure which is always present ..... 4
4. All the anthers densely white-bearded near tip..... 5
5. Corolla-tube 8.0 to 10.5 mm. long; filament-tube 5.0 to 7.5 mm. long; leaves linear or broader, toothed; capsule about half-inferior..... 6
6. Upper leaves 2 to 6 mm. wide; lower leaves broader, 1.0 to 2.5 cm. wide; northeastern Mexico..... *L. Ehrenbergii* var. *Ehrenbergii*, p. 695
6. Upper leaves 2 mm. wide or less; lower leaves 3 mm. wide or less; Chihuahua and Durango ..... *L. Ehrenbergii* var. *gracilens*, p. 695
5. Corolla-tube 7.5 mm. long; filament-tube 4.5 to 5.0 mm. long; leaves linear-filiform, about 0.5 mm. wide, entire or essentially so; ovary (and capsule?) superior ..... *L. Dielsiana*, p. 694
4. The three larger anthers glabrous or pubescent on the backs, not densely white-bearded at tips; two smaller anthers white-tufted at tip..... 7
7. Capsule much less than half-inferior; corolla-tube 11 to 14 mm. long, narrowly linear and slightly curved, the dorsal slit extending to a point 2.5 to 4.5 mm. from base; Nuevo Leon and Tamaulipas..*L. sublibera*, p. 694
7. Capsule at least half-inferior; corolla-tube 10 mm. long or less, the dorsal slit extending to a point 2 mm. from base or less; southern and western Mexico ..... 8
8. Pedicels in fruit mostly 10 to 15 mm. long; hypanthium and calyx-lobes mostly glabrous; hypanthium in anthesis distinctly longer than wide when pressed; filament tube 3.5 to 5.0 mm. long; Durango to Arizona and New Mexico..... *L. anatina*, p. 688
8. Pedicels in fruit mostly 3 to 7 mm. long; hypanthium and calyx-lobes usually prickly-pubescent; hypanthium in anthesis about as wide as long when pressed; filament-tube (4.5) 6.0 to 12.0 mm. long; Durango to Oaxaca.....8a
8a. Filament-tube 4.5 to 6.5 mm. long; anther-tube usually white-pubescent; middle cauline leaves usually 3 to 5 (rarely 8) times as long as wide; Oaxaca and Guerero....*L. gruina* var. *peduncularis*, p. 687
8a. Filament-tube (6.0) 8.0 to 9.0 (12.0) mm. long; anther-tube usually glabrous except for the terminal tufts of the two shorter anthers; middle cauline leaves often 10 times as long as broad; region of Mexico City and northward, rarely south to Oaxaca..... ..... *L. gruina* var. *gruina*, p. 687

1. Corolla-tube less than 7.0 mm. long (usually 5.0 mm. long or less); filament-tube usually 5.0 mm. long or less ..... 9

9. Flower, including hypanthium, 4.0 to 7.0 mm. long (average about 6.0 mm. or less); anther-tube 0.5 to 1.0 mm. long; seeds smooth and shining; annuals, native to the West Indies, Central and South America and southern Mexico (dwarfed individuals of *L. Berlandieri* and *L. divaricata* may key out here; see second 9 in case of doubt) ..... 10

10. Pedicels smooth and glabrous, mostly 10 to 15 mm. long in fruit; plants glabrous with scattered hairs; capsule about half inferior; native to the Greater Antilles ..... *L. Cliffortiana*, p. 696

10. Pedicels granular-puberulent to rough hispidulous (rarely glabrous in *L. fastigiata*, in which the capsule is almost wholly inferior); plants somewhat pubescent, at least below; capsules various ..... 11

11. Mature capsule 1/3 inferior or less ..... *L. xalapensis*, p. 695

11. Mature capsule 3/4 inferior or more ..... 12

12. Leaves mostly radical; plants 15 cm. high or less; native of the Bahama Islands ..... *L. lucayana*, p. 696

12. Plants leafy-stemmed, normally more than 15 cm. high; Yucatan and Trinidad to northern South America ..... 13

13. Pedicels in fruit 2.0 to 7.0 mm. long, spreading-ascending, finely granular-roughened or nearly smooth ..... *L. fastigiata*, p. 696

13. Pedicels in fruit 13.0 to 15.0 mm. long, strongly divaricate, straight, minutely hispidulous ..... *L. yucatana*, p. 696

9. Flower, including hypanthium, 6.5 mm. long or more (usually at least 10 mm. long); anther-tube 1.0 mm. long or more; seeds, duration and range various ..... 14

14. Corolla-tube usually prominently fenestrate and noticeably shorter than the lower lip of the corolla; all 5 anthers densely white-bearded at tip (except *L. umbellifera*), included, with the short (3.0 mm. or less) filament-tube, in the corolla-tube; pedicels mostly less than 10 mm. long in fruit, minutely hispidulous, often purplish ..... 15

15. Inflorescence sub-umbellate, the 1 to 6 flowers arising nearly together; leaves, at least the lower, obtuse at tip; blades 1.5 cm. long or less, 1.5 to 6.5 times as long as wide, elliptic; Guatemala and adjacent Chiapas ..... *L. umbellifera*, p. 698

15. Inflorescence racemose or spicate, elongated, at least in fruit; leaves except sometimes the lowermost, acute at tip; blades mostly longer than 2.5 cm., lanceolate or oblong to linear ..... 16

16. Leaves coarsely serrate, the middle and upper ones lanceolate or oblong, mostly 0.6 to 1.2 cm. wide; plants annual or biennial, with a woody taproot; corolla-tube 5 to 6 mm. long ..... *L. fenestralis*, p. 696

16. Leaves crenate or subentire to remotely and shallowly serrate, the middle and upper ones linear to lanceolate, 0.15 to 0.6 cm. wide; plants perennial, with clustered or fleshy roots; corolla-tube 4.0 mm. long or less (except in *L. poetica*, which has narrowly linear leaves) ..... 17

17. Corolla-tube 4.5 to 5.0 mm. long; filament-tube 3.0 mm. long; flower 14 to 17 mm. long, including the hypanthium, which is flat in anthesis or essentially so ..... *L. poetica*, p. 697

17. Corolla-tube 4.0 mm. long or less; filament-tube 2.0 mm. long or less; flower 8 to 14 mm. long, including the obliquely short-campanulate or cup-shaped hypanthium ..... 18

18. Calyx-lobes strongly reflexed, even in the flower; leaves linear-elliptic, attenuate at base and apex; capsule almost wholly inferior, 3 mm. long or less, truncate at base; bracteoles at base of pedicel filiform, evident ..... *L. jaliscensis*, p. 697

18. Calyx-lobes ascending or erect, never strongly reflexed; leaves linear to lanceolate, sessile, the base as broad as the blade or essentially so, often sub-clasping; capsule ½ to ¾ inferior, 3.0 to 5.0 mm. long, rounded or acute at base; bracteoles usually hidden or wanting ..... 19

19. Anther-tube 1.0 to 1.3 mm. long; seeds dull or slightly lustrous, with faint longitudinal lines ..... 20

20. Corolla blue, the tube usually fenestrate; flower, including hypanthium, 8.0 to 10.5 mm. long; Costa Rica and Panama ..... *L. irasuensis* var. *irasuensis*, p. 697

20. Corolla light-blue or white, conspicuously dark-blue-veined; tube not fenestrate; flower, including hypanthium, 12 to 13 mm. long; State of Mexico..... *L. irasuensis* var. *picta*, p. 697

19. Anther-tube 1.5 to 2.0 mm. long; seeds highly polished, with no lines visible at a magnification of 20×; corolla light, with dark blue veins, the tube fenestrate; State of Durango..... ..... *L. irasuensis* var. *fucata*, p. 697

14. Corolla-tube usually about equalling or exceeding the lower lip; the 3 larger anthers glabrous or pubescent, not densely bearded at tip, usually exserted; filament-tube (2.5) 3.0 mm. long or more, usually partially exserted; pedicels various, usually 10 mm. long or more, rarely if ever both prickly-pubescent and purplish ..... 20

20. Corolla-tube not fenestrate, entire except for the dorsal fissure, which extends to a point near base (not more than 2.5 mm. from base)..... 21

21. Flower-bracts or subtending leaves all foliaceous, at least the lower ones indistinguishable from the foliage leaves, the middle and upper ones narrower, sometimes linear, the uppermost 1.0 to 1.5 cm. long; bracteoles of the pedicel usually none ..... 22

22. Plants erect or decumbent, the stems 15 to 50 cm. high; leaves coarsely toothed, mostly lanceolate to ovate, 2.5 to 8.0 cm. long; inflorescence terminal, bearing few to 25 flowers....*L. longicaulis*, p. 693

22. Plants from a stout upright rootstock, the stems several, delicate, 5 to 20 cm. long, usually creeping and rooting at the nodes; leaves sinuate, denticulate, crenate or subentire, mostly spatulate or oblanceolate, mostly less than 2.5 cm. long; flowers 2 to 4, solitary in the axils of ordinary leaves, on erect pedicels 7 to 160 mm. long (usually 30 to 60) ..... *L. nana*, p. 688

21. Flower-bracts linear or subulate, none or only the lowermost foliaceous, all (or all except the lowermost) less than 1 cm. long, much smaller than and sharply contrasted to the foliage leaves; bracteoles of the pedicels mostly present ..... 23

23. Entire plant somewhat hoary, covered with short, whitish hairs; leaves cauline, practically entire, the margins slightly sinuate, the very few callosities hidden by the hairs..... *L. illota*, p. 689

23. Plants glabrous or somewhat hairy below, never white-hoary; leaves cauline or partly or wholly basal, with toothed or denticulate blades, the callosities usually plainly visible to the unaided eye..... 24

24. Mature capsule 1/3 inferior or less, (free part of ovary in anthesis longer than the hypanthium) ..... 25

25. Flower, including hypanthium, 16 to 20 mm. long; capsule 7 to 9 mm. long ..... *L. pulchella*, p. 694

25. Flower, including hypanthium, 10 mm. long or less; capsule 6 mm. long or less ..... 26

26. Pedicels bracteolate at base; filament-tube about 3.0 mm. long; annuals, native of peninsular Florida..... *L. homophylla*, p. 695

26. Pedicels ebracteolate; filament-tube 4.0 to 4.8 mm. long; perennials, native of southern Mexico....*L. diastateoides*, p. 695

24. Mature capsule half infe.ior or more (free part of ovary in anthesis sho:ter than hypanthium.) .....27

27. Flower 14 to 16 mm. long, including hypanthium; plants glabrous, 10 to 15 cm. high, from a short upright perennial rootstock which also sends out filiform leafy stolons; native of high mountains of Guatemala .....*L. stolonifera*, p. 688

27. Flower 13 mm. long or less, including hypanthium; plants annual or perennial, not stoloniferous, usually not entirely glabrous.....28

28. Seeds roughened with faint longitudinal markings, these plainly visible with a magnification of 20× .....29

29. Leaves linear, oblanceolate, or narrowly lanceolate, mostly 0.3 cm. wide or less and 7 to 12 times as long as wide; plants glabrous or very nearly so.....*L. Purpusii*, p. 689

29. Leaves lanceolate to ovate, the larger ones 0.5 cm. wide or more, 1.5 to 6 times as long as wide, or, if narrower, plants pubescent throughout .....30

30. Leaves basal, the blades with prominent white veins above; capsule 4 mm. long or less.....*L. subnuda*, p. 689

30. Leaves cauline or basal, green; capsule mostly 4.0 to 6.0 mm. long .....*L. Sartorii*, p. 688

28. Seeds smooth, highly polished and shining, without longitudinal markings .....31

31. Plant perennial from a heavy woody base, the numerous stems decumbent; leaves cauline, elliptic, long-attenuate at base; leaves and lower part of stem densely clothed with fine sharp spreading often brownish hairs; native of Nuevo Leon .....*L. Pringlei*, p. 690

31. Plants annual or perhaps sometimes perennial; if perennial, not as above; leaves various; stems glabrous or the lower part sparsely pubescent or scabrous .....32

32. Pedicels in fruit 4 to 10 (12) mm. long, strongly ascending, the tips little or not at all incurved, and the capsule thus more or less erect .....33

33. Calyx-lobes ciliate near tips on margins; stems and leaves green (exceptionally purplish), glabrous or essentially so, not hispidulous.....*L. brachypoda*, p. 692

33. Calyx-lobes smooth and glabrous; stems purplish below, wiry, usually hispidulous .....*L. divaricata*, p. 692

32. Pedicels in fruit 12 (rarely 10) mm. long or more, spreading, divaricate or the tips strongly incurved, the capsule then facing the stem; calyx-lobes glabrous .....34

34. Stems purplish below, wiry, usually hispidulous; pedicels erect or divaricate, often much elongated, the tips usually not incurved; cauline leaves elliptic, usually 0.7 cm. wide or less; San Luis Potosi westward and southward.....*L. divaricata*, p. 692

34. Stems green (exceptionally slightly purplish below), glabrous or essentially so, not hispidulous; pedicels and capsules usually strongly incurved; cauline leaves elliptic to ovate-cordate, at least the middle ones 1.0 cm. wide or more; northern Vera Cruz to southern Texas .....*L. Berlandieri*, p. 690

20. Corolla-tube fenestrate laterally near base ..... 35

35. Pedicels ebracteolate; calyx-lobes sparingly toothed; capsule 8 to 10 mm. long, about half inferior; leaves conspicuously and evenly incised-serrate, long-acuminate at tip, cuneate at base..*L. stenodonta*, p. 693

35. Pedicels bracteolate; calyx-lobes entire; capsule 6 mm. long or less; leaves not as above, the margins subentire or irregularly toothed..... 36

36. Ovary and capsule wholly superior or nearly so; pedicels strongly hispidulous ..... *L. hypnodes*,[2] p. 698

36. Ovary and capsule ½ to ⅔ inferior; pedicels glabrous or essentially so, never hispidulous ..... 37

37. Seeds with longitudinal markings, these easily visible with a magnification of 20×; pedicels spreading-ascending, usually arcuate, the the mature capsule incurved; capsule 3.0 to 6.0 mm. long, usually slightly more than half inferior (sometimes as much as ⅔ inferior), the hypanthium hemispheric to long-campanulate..... *L. Sartorii*, p. 688

37. Seeds plainly impressed-reticulate, not longitudinally roughened; pedicels stiffly divaricate, the mature capsule not at all incurved; capsule 3.5 mm. long or less, about half-inferior, the hypanthium hemispheric ..... *L. tarsophora*, p. 698

### 1. **Lobelia gruina** Cav. var. **gruina** nom. nov.

*Lobelia gruina* Cav., Ic. **6**:8. t. 511. f. 2. 1801.

The type was collected in southern Mexico; a fragment of the type material, from the Née herbarium, is now in the Field Museum and is clearly the species as here understood. The range is from (Nuevo Leon ?) San Luis Potosi and Durango to Oaxaca. *L. gruina* var. *conferta* Fernald (Proc. Amer. Acad. 36: 503. 1901) is of occasional occurrence throughout the range, and may be designated as **L. gruina,** forma **conferta** (Fernald) comb. nov.

### 1a. **Lobelia gruina** Cav. var. **peduncularis** var. nov.

A var. gruina filamentis 4.5-6.5 mm. longis, foliis lanceolatis ovatisve plerumque serratis, pedunculo sub spicam 10-20 cm. longo, differt.

This variety has not been collected except in the states of Oaxaca and Guerrero, at altitudes between 1500 and 2700 meters. It is strikingly similar in aspect to *L. Hartwegi* A.DC., the shape and toothing of the leaves and the amount and kind of pubescence being almost identical in the two species. It differs from var. *gruina* in several respects: the leaves in var. *peduncularis* are usually proportionately broader than in var. *gruina*, and more strongly serrate; the stems are more densely pubescent and the naked part of the stem ("peduncle") is, on the average, slightly longer. The filament-tube is shorter and less exserted in var. *peduncularis*, while the anther-tube is usually covered with white hairs in var. *peduncularis* and naked in var. *gruina*. The short anther-tube is reminiscent of that of *L. anatina*, from which var. *peduncularis* may be

[2] This species and *L. tarsophora* are doubtfully members of this section. Their seeds place them rather with section *Eulobelia*, but in other respects they seem to be much nearer the various species of *Hemipogon*. Their geographic affinities are with *Hemipogon*, and they are perhaps to be considered as intermediate between the two sections.

distinguished by the short (3 to 8 mm.) pedicels and the dense and uniformly distributed pubescence, as well as the long-pedunculate spike.

*Specimens examined:* GUERRERO: "Between Ayusinapa and Petatlan," *Nelson 2124* (GH, US).—OAXACA: Sierra de San Felipe, C. *L. Smith 723*, Oct. 13, 1894 (US); Sierra de San Felipe, *Pringle 5688*, Oct. 13, 1894 (GH, Type); "Mts. of Telixtlahuaca," *L. C. Smith 859* (GH); "zwischen Yanhuitlan & Teposcolula," *Seler 1416* (GH).

2. *Lobelia anatina* E. Wimm., Rep. Sp. Nov. 19:385. 1924.

This is the species which, in southwestern United States and northwestern Mexico, has passed as *L. gruina*, which it resembles in vegetative characters. It appears, however, to be amply distinct by virtue of its geographical range, as well as by the characters outlined above in the key. The corolla of *L. anatina* is quite different from that of *L. gruina* as shown in the accompanying figures (figures 19 and 20). In the former the corolla-tube is nearly cylindric and about equaling the lobes in length; the lobes themselves are spreading and scarcely united at base; in *L. gruina* the tube is usually prominently widened distally and the rather short lobes are partially fused into a sharply reflexed lip.

3. *Lobelia nana* H.B.K., Nov. Gen. & Sp. 3:317. t. 272 (folio ed. p. 247) 1819. Chihuahua to Vera Cruz & Chiapas; Colombia to Argentina & Chile.

4. *Lobelia stolonifera* Donn. Sm., Bot. Gaz. 27:338. 1899.

In fruit and flower characters this species is very close to the preceding, from which it is easily distinguished by its upright flowering stems. It is also closely related to the Andean *Lobelia tenera* H.B.K. In addition to the type collection, the plant is known from the following: "alpine meadows, 10500 feet, Llanos of Sierra Cuchumatanes, Dept. Huehuetenango, Guatemala, *A. F. Skutch 1099*. (F).

5. *Lobelia Sartorii* Vatke, Linnaea 38:721. 1874.

*L. novella* Robinson, Proc. Amer. Acad. **26**:167. 1891; *L. piscinula* E. Wimm., Rep. Sp. Nov. **38**:84. 1935; *L. calcarea* E. Wimm., Rep. Sp. Nov. **38**:83, pro parte. 1935.

This species shows great variation in shape, texture and pubescence of leaves, as well as in the character of the toothing of the margins. There appears to be, however, a completely intergrading series of specimens from those with cordate leaves and dense pubescence (*L. novella* was of this type) to those with almost linear leaves, with or without pubescence. The writer has been unable to correlate these leaf-variations either with characters of flower or fruit or with geographic range. Such variation in leaf-shape is not uncommon in the *Lobelioideae* and, in the writer's opinion, is of insufficient value to determine specific limits. The plant described by Wimmer as *L. piscinula* was a lanceolate-leaved form which is apparently the commonest representative of the species in central Guatemala. It seems to be restricted to Guatemala and extreme southern Mexico, and perhaps should be designated as a variety.

*Representative specimens examined:* MEXICO (State unknown); Calvestros, *Liebmann pl. mex. 9211* (C; cited by Wimmer as *L. calcarea*); Pital, *Liebmann pl. mex. 9225* (C); Sta. Cruz, *Liebmann pl. mex. 9229* (C); Dos Fuentes, *Liebmann pl. mex. 9207* (C).—SAN LUIS POTOSI: Tamasopo Canyon, *Pringle 3288* (type collection of *L. novella*) (GH, Type, F, NY, OB, PH, US); *Pringle 4015* (US).—VERA CRUZ: Orizaba, *Liebmann pl. mex. 9210* (C); *Fred Müller 1526* (NY); *Bourgeau 2923* (GH, US); *Botteri 200* (GH); Maltrata, *Matuda S-57* (F) and *1197* (F); Fortuño, Coatzacoalcos R., *Williams 9047* (F).—OAXACA: Totontepec, *Nelson 719* (US); Zempoaltepec, *Nelson 577, 682* and *689* (US); Zempoaltepetl, *Camp 2684* (NY).—TABASCO: "Margines del Grijalva" *Rovirosa 410, p.p.* (PH).—CHIAPAS: San Richardo to Ocozucaautla, *Nelson 2963* (US); Tuxtla, *Seler 1909* (GH); without locality, *Ghiesbreght 141* and *831* (GH).—GUATEMALA: Alta Verapaz; Coban, *von Tuerckheim II 1026* (GH,NY); Baja Verapaz; Santa Rosa, *von Tuerckheim II 1552* (GH, NY, US); Quiché; S. Miguel Uspantan, *Heyde & Lux, Pl. guat. J. D. Sm. 2873* (GH, NY, US).

6. *Lobelia subnuda* Benth., Pl. Hartw. 44. 1840.

At first sight this plant seems abundantly distinct from all other species, being set off by its scapose habit and its small ovate-cordate white-veined leaves. When all the available collections are examined, however, in conjunction with a series of specimens of *L. Sartorii,* the differences between the two species are seen to be very minor ones. The scapose habit of *L. subnuda* is exactly matched by some small individuals of *L. Sartorii,* as are the ovate-cordate leaves. The flowers, fruits and seeds of the two appear identical. The only remaining difference lies in the variegated leaves of *L. subnuda.* With the exception of the type collection, however, the writer has been able to locate but a single specimen of *L. subnuda* (Trinidad, State of Hidalgo, *Pringle* 13406 (US)), and hesitates to make positive statements in regard to its status. For the present it may be regarded as a species very closely related to *L. Sartorii.*

7. *Lobelia Purpusii* Brandegee, Univ. Calif. Publ. Bot. 4:190. 1911.

This species, like the preceding, is doubtfully distinct from *L. Sartorii.* The differences lie in the leaves, which in *L. Purpusii* are linear or essentially so, numerous, and glabrous; in some forms of *L. Sartorii,* however, these characters are matched almost exactly. Again the conservative course seems to be to let final disposition of the case wait upon additional collecting.

*Specimens examined:* MEXICO (state unknown); "n.w. Mexico," *Seemann* (NY); "Mexico, ad rivulos, Rancho de la Gallota," *Hartweg 335* (NY).—SAN LUIS POTOSI: Rascon, Rio de la Gallinas, *Purpus 5700* (GH); Tamasopo Canyon, *Pringle 3664* (GH).—VERA CRUZ: Teocelo Falls, *Rhoads,* Mar. 1899 (PH); Mirador, *Liebmann pl. mex. 9227* (C); Zacuapan, *Purpus 4933* (type collection) (F, GH).

8. **Lobelia illota** sp. nov.

Herba canescens. Caules ramosi, decumbentes. Folia late elliptica, subintegra, petiolata. Semina elliptica, obtusa, nitida. A spec. ceteris sect. Hemipogonis caulibus, foliis racemoque canescentibus differt.

A species which is known only from the type collection. The TYPE is *J. N. Rovirosa 900,* collected "in montibus argentiferis Zacualpan, Chiapas," and now in the Academy of Natural Sciences, Philadelphia.

A straggling herb 20 cm. high or less, the whole plant uniformly covered with white, spreading somewhat crisped hairs which give it a grayish or glaucous appearance. The leaf-margins are sinuate and apparently entire, the few tiny callose teeth being hidden by the covering of hairs. The flowers and fruits apparently differ but little from those of related species.

9. *Lobelia Pringlei* S. Wats., Proc. Amer. Acad. 25:157. 1890.

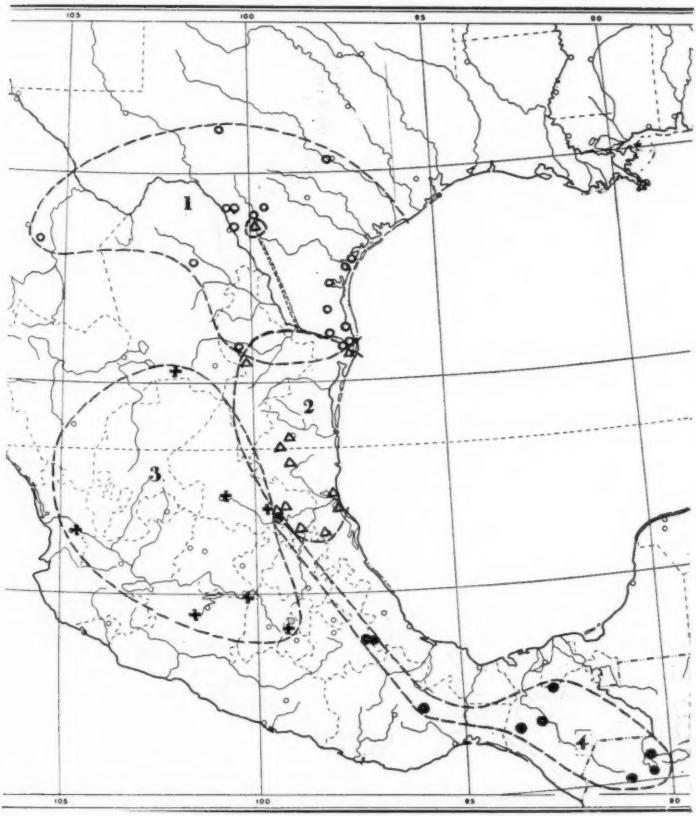
Known only from the mountains of Nuevo Leon, and distinguished from its close relatives by its perennial habit and woody base, and its peculiar brownish pubescence at the base of the stems and on the leaves.

10. *Lobelia Berlandieri* A.DC. in DC. Prodr. 7:367. 1839.

The most difficult taxonomic problems in the study of North American lobelias are presented by this species and two or three related ones. *Lobelia Berlandieri* was first described from a specimen collected in the vicinity of Tampico, Tamaulipas. The specimen in question was a small weak plant with decumbent stems and a basal rosette of leaves but with cauline leaves practically absent. *(Berlandier 106)*. Plants having this habit were assumed by later botanists to be *L. Berlandieri,* and those having an upright stem and ovate-cordate cauline leaves (even from the same localities!) were taken to be varieties of *L. Clifortiana.* In 1935 Wimmer described *L. calcarea* to include some of these erect plants and some specimens of *L. Sartorii* as well. Examination of the available herbarium material shows that the plants with well-developed basal rosettes, a type common along the coast and in the uplands of Tamaulipas, are conspecific with the coarse upright plants with cauline leaves, which are found from Tamaulipas to northern Vera Cruz and inland to the mountains of Nuevo Leon and eastern San Luis Potosi. The name *Lobelia calcarea,* which was applied to the latter type, in part, thus passes into synonymy.

From the southern tip of Texas to the vicinity of Monterey, Nuevo Leon, the geographic range of *L. Berlandieri* lies adjacent to that of *L. brachypoda* Small, which is usually easily distinguished by its stouter stems, ciliate calyx-lobes, shorter pedicels and upright (not incurved) capsules. Certain individuals from this area are apparently intermediates and not to be assigned to either species; there are, however, very few of these and the writer is unable to determine their exact status. In view of the very considerable morphological differences between the bulk of the material of *L. Berlandieri* and that of *L. brachypoda,* it does not seem possible at the present time to consider them conspecific.

From the vicinity of Monterey, southward and westward into Coahuila and San Luis Potosi, one meets with occasional plants having the slender, almost wiry, purplish and hispidulous stems of *Lobelia divaricata* H. & A., combined with the obovate or spatulate basal leaves and decumbent stems of some forms of *L. Berlandieri.* Typical *L. divaricata* ranges from San Luis Potosi to Nayarit and southward to the highlands about Mexico City; in its most characteristic form it appears to be quite distinct from any other species, and the above-mentioned intermediates may represent hybrids or merely extreme forms of *L. divaricata.*




Map. 1. (1) Range of *Lobelia brachypoda* Small. (2) Range of *L. Berlandieri* A.DC. (3) Range of *L. divaricata* Hook. & Arn. (4) Range of *L. Sartorii* Vatke.

The symbols representing actual collectors' localities are slightly misplaced in eastern San Luis Potosi, since *L. Berlandieri*, *L. divaricata* and *L. Sartorii* have all been found in the vicinity of Cardenas and it was impossible to superimpose the three corresponding symbols without loss of clarity.

Finally, *L. Berlandieri*, in some of its forms, is scarcely to be distinguished from forms of *L. Sartorii* except by means of the mature seeds; the two differ also, however, in the capsule, which in *L. Berlandieri* is usually much more than half inferior, as contrasted to that of *L. Sartorii*, which is hardly ever more than half inferior.

*Representative specimens examined:* TEXAS: Brazos Santiago, *Nealley* (US); El Jardin, *Runyon 40* (US).—TAMAULIPAS; "Tamaulipas," *Runyon & Tharp 4035* (TEX, US); Matamoros, *Berlandier 3177* (GH); Tampico, *Palmer*, June 1910 (US); Victoria, *Palmer 65* (F, NY, US); Gomez Farias, *Palmer 328* (F, NY, US); sierra near Jaumave, *von Rozynski 351* (F,NY); base of mts. near Victoria, *Runyon 940* (TEX, US).—NUEVO LEON: near Linares, *Kemp*, Jan. 1902 (NY); Monterey, *Gregg*, Jan. 1830 (GH); both the preceding are doubtfully of this species, and may be depauperate forms of *L. brachypoda;* near Monterey, *Pringle 2261* (GH) and *13744* (GH, US).—VERA CRUZ: Pueblo Viejo, 2 km. s. of Tampico, *Palmer 369* (F, NY); Wartenberg, near Tantoyuca, prov. Huasteca, *L. C. Ervendberg 308* and *249* (GH).—SAN LUIS POTOSI: Tamasopo Canyon, *Pringle 3369* (F, GH, NY, OB, PH, US); San Dieguito, *Palmer 91* (F, NY, US); Tancanhuitz, *Nelson 4390* (GH, US); Rascon, *Purpus 5555* (GH).

11. *Lobelia brachypoda* A.DC., ex Small, Fl. S.E.U.S. 1147. 1903.

*L. Cliffortiana* var. *brachypoda* A. Gray, Syn. Fl. N. Am., ed. 2, **2**, pt. 1:7, 1886.

The name of this species, as published by Small, is apparently based upon Gray's var. *brachypoda*, and erroneously attributed to DeCandolle. Small, however, in his list of new names and combinations at the end of his flora, fails to mention this species and gives no indication as to the source of the name. We must, accordingly, cite it as given above, without assuming that it was based upon Gray's varietal name.

As discussed above under *L. Berlandieri*, the present species is distinct from all others except in the southern part of its range, where a few apparently depauperate individuals may resemble forms of *L. Berlandieri*. Central and southern Texas, particularly near the coast, west to northern Chihuahua and south about to Monterey, Nuevo Leon, and to central Coahuila.

*Representative specimens examined:* (Abundant Texas material not cited)—CHIHUAHUA: Ortiz, *Pringle 1479* (GH).—COAHUILA; Muzquiz, *Marsh 180* (F); Santa Rosa, *Schott* (F).—TAMAULIPAS; "Environs de Matamoros," *Berlandier* in 1838 (GH).—NUEVO LEON; Monterey, *Bro. Arsene 6105* (GH, US); Monterey, *Palmer 772* (GH).

12. *Lobelia divaricata* Hook. & Arn., Bot. Beech. Voy. 301. t. 67, 1840.

*Rapuntium pusillum* Presl, Prodr. Mon. Lob. 22. 1836; *Lobelia pusilla* A.DC. in DC. Prodr. **7**:379. 1839, non G. Don, 1834. *Lobelia Scleriana* E. Wimm., Rep. Sp. Nov. **38**:82, *pro parte*. 1935. *Lobelia trivialis* E. Wimm., Rep. Sp. Nov. **38**:83. 1935.

The TYPE of *Lobelia divaricata* is a small specimen with weak stems; the plants are entirely glabrous, with short pedicels. The only additional material, seen by the writer, which matches this exactly is Palmer's no. 1868, from Tepic. This is practically identical with the type material, as might be expected, the original collection having been made near Tepic. Most of the other specimens in herbaria are slender but with the stems quite erect, spreading- or retrorsely

hispidulous, with elongated pedicels (these sometimes 50 to 70 mm. long); this is the plant described as *L. Seleriana*. The TYPE of *Rapuntium pusillum* (PR, no. 495566) is of this general sort. Both types of plant occur throughout the range, the slender erect sort with a basal rosette and long pedicel being the more frequent. *Lobelia trivialis* was described from specimens collected in San Luis Potosi, and apparently represents one of the intermediates between typical *L. divaricata* and *L. Berlandieri*.

*Representative material examined:* MEXICO (state unknown): "RDM (Real del Monte?) to Zacatecas," *Dr. Coulter 26* (K; this is habitally like the TYPE, but has hispidulous stems); "Mexico," *Haenke* (PR; TYPE of *Rapuntium pusillum*); "Mexico," *Beechey* (K; TYPE).—MEXICO (D.F.); Eslava, *Lyonnet 1917* (US).—MICHOACAN; vicinity of Morelia, *Arsene 6068* (GA, GH, NY, US); Patzcuaro, *Seler 1225* (GH, NY).—NAYARIT: Tepic, *Palmer 1868* (F, GH, NY, US).—SAN LUIS POTOSI; San Luis Potosi, *Parry & Palmer 556* (F, GH, US); "Ex convalli San Luis Potosi," *Schaffner 528* (NY); *Schaffner 119* (GH); "in paludosis circa Morales," *Schaffner 737* (GH); Cardenas, *Pringle 3301* (GH, NY, MICH, OB, US); Guascama, Minas de San Rafael, *Purpus 5556* (F, GH, NY, US); Agua Media, *Purpus 4918* (Type collection of *L. trivialis*) (F, GH).—COAHUILA; Sierra de Pata Galana, *Purpus 1119* (F, GH, NY).

All of the specimens cited from San Luis Potosi and Coahuila show some of the features discussed above in connection with *L. Berlandieri*. Part or all of every collection will include plants with short pedicels or somewhat decumbent stems. As previously explained, the status of these specimens is not certain, but they seem best included in *L. divaricata* unless evidence to the contrary is provided.

13. *Lobelia stenodonta* (Fern.) McVaugh, Bull. Torr. Bot. Club 67:144. 1940.

*Heterotoma stenodonta* Fern., Proc. Amer. Acad. **36**:504. 1901.

Easily recognized by its peculiarly shaped and incised-serrate leaves. Chiapas and Oaxaca.

14. *Lobelia longicaulis* Brandegee, Univ. Calif. Publ. Bot. 6:73. 1914.

*Lobelia neglecta* Vatke, Linnaea **38**:720. 1874, *non* R. & S., 1819. *Lobelia poasensis* E. Wimm., Ann. Naturhist. Mus. Wien **46**:239. 1933. *Lobelia urticifolia* E. Wimm., Rep. Sp. Nov. **22**:195. 1926.

A coarse and somewhat weedy species, often with numerous stems; the roots are characteristically woody or somewhat fleshy. The flower-bracts are leafy, often being as large as the other leaves. The plant is variable in aspect, its habit evidently depending upon the environment. Individuals from shady situations often have large membranous leaves, while plants from drier, sunny places often have the leaves much smaller and thicker; the stems may be elongated, with flowers at most of the nodes, or short and erect, with the flowers clustered in the upper axils.

*Representative material examined:* MEXICO (state unknown): "Mexico," *Ehrenberg 520* (TYPE of *L. neglecta* Vatke) (B); Ixtaccihuatl, *Purpus 62* (POM,US).—MEXICO (state): Comunidad, dist. Temascaltepec, *Hinton 4401* (GH).—MEXICO (D.F.): Serrania de Guadalupe, *Lyonnet 1514* (US).—MICHOACAN; Zitacuaro, *Hinton 11905*

(LA).—MORELOS; Cuernavaca, *Pringle 6337* (F, GH, NY, PH, US).—CHIAPAS; Finca Covadonga, *Purpus 6697* (type collection) (F, GH, NY); near San Cristobal, *Nelson 3212* (US).—GUATEMALA; Tecpam, dep. Chimaltenango, *Skutch 537* (MICH, NY, US); Volcan de Agua, Dep. Sacatepequez, *Standley 65169* (F).—COSTA RICA; Volcan de Poas, *Cufodontis 605* (F, Isotype of *L. poasensis*); Vol. de Turrialba, *Standley 35203* (GH, US); Massif du Barba, *Tonduz 332 bis* (US); Massif del Irazu, *Tonduz 4287* (US); near San José, *Pittier 332b* (US).—PANAMA; Chiriqui, Finca Lerida to Boquete, *Woodson et al. 1119* (USNA).

The plant described by Wimmer as *Lobelia plebeia* (Rep. Sp. Nov. 22:194. 1926) is very closely related to the above species and probably not distinct from it. The only differences lie in the flower-bracts, which in *L. plebeia* tend to be linear and elongated rather than broad like the foliage leaves, and in the root systems; in *L. longicaulis* the roots are stout and woody, or tuberous, whereas all the plants of *L. plebeia* examined by the writer have a short woody base with numerous fibrous roots, the plants often appearing to be annual in duration. The bract-character mentioned above is not a constant one, numerous intergrading forms occurring throughout the range, and, as the distinction between annuals and perennials is a nebulous one in tropical and subtropical regions, the safest course at present is to submerge *L. plebeia* in *L. longicaulis*. Additional collections of this plant are needed.

*Specimens examined:* MEXICO (state unknown); "Inter S. Andrea & S. Miguel," *Liebmann pl. mex. 7722* (TYPE of *L. plebeia*) (C).—MEXICO (state); Comunidad, dist. Temascaltepec, *Hinton 2450* (GH); Los Hornos (?), dist. Temascaltepec, *Hinton 5086* (GH).—OAXACA; Sierra de San Felipe, *Pringle 5681* (GH); Sierra de Reyes, *Pringle 5797* (GH).—CHIAPAS; *Mt. Orando, Matuda 474* (US).

15. *Lobelia pulchella* Vatke, Linnaea 38:720. 1874.

*Lobelia bryophila* E. Wimm., Rep. Sp. Nov. **19**:385. 1924. *Lobelia setulosa* E. Wimm., Rep. Sp. Nov. **19**:386. 1924.

Southern Mexico, from Oaxaca to Guerrero.

The TYPE, in the Berlin Herbarium, is labelled simply "Mexico," and is somewhat more pubescent than any other collection seen by the writer. It appears not to differ otherwise, however, from modern collections from Oaxaca, including *Pringle 6002* (F, GH, NY, US), the type-collection of *L. bryophila*. The TYPE of *L. setulosa*, collected by Galeotti in Oaxaca, and now in the Delessert Herbarium, has not been examined, but from the original description and from a photograph furnished by Prof. Hochreutiner it seems to correspond closely to the TYPE of *L. pulchella*. A collection made by Camp on Zempoaltepetl (*Camp 2632*, NY) has the flowers and fruits nearly twice as large in all parts as typical *L. pulchella* but agrees well otherwise.

16. *Lobelia sublibera* S. Wats., Proc. Amer. Acad. 25:157. 1890.

An easily-recognized, large-flowered species, allied to the preceding by characters of corolla and capsule.

17. *Lobelia Dielsiana* E. Wimm., Rep. Sp. Nov. 22:194. 1926.

A very distinctive species, set off from all others by the linear-filiform

leaves and the superior ovary. It is known only from the type collection, made in the mountains of Michoacan or Guerrero.

18. **Lobelia Ehrenbergii** Vatke var. **Ehrenbergii** nom. nov.

*L. Ehrenbergii* Vatke, Linnaea **38**:719. 1874.

This species has been collected but rarely. Abundant material secured by Dr. C. H. Muller in Nuevo Leon in 1939 shows the considerable leaf-variation in the species, and indicates that the plant is not more than varietally distinct from *L. gracilens* Gray. Gray himself cited no. 29 of Dr. Thomas Coulter's Mexican collection in the original description of *L. gracilens*, with the note that it was probably a larger-leaved form of the same species.

*Specimens examined:* MEXICO (state unknown); "Mexico," *Dr. Coulter 29* (GH, NY); "pr. los Encarnacios," *Ehrenberg* (B; TYPE).—NUEVO LEON: trail from Trinidad to Sa. de la Cibola, Mun. Montemorelos, *Muller 2875* (USNA).

18a. **Lobelia Ehrenbergii** Vatke var. **gracilens** (A. Gray) comb. nov.

*Lobelia gracilens* A. Gray, Proc. Amer. Acad. **21**:393. 1886.

Sometimes confused with *L. anatina*, from which it is easily distinguished by the larger flowers and the tufted anthers.

*Representative specimens examined:* CHIHUAHUA: "south-western Chihuahua," *Palmer 360* (GH (TYPE), NY, PH, US); Sierra Madre near Colonia Garcia, *Townsend & Barber 259* (F, GH, NY, US).—DURANGO: without locality, *P. Ibana Garcia 449* (US).

19. **Lobelia diastateoides** sp. nov.

Herba perennis, simplex; caules inferne hirtelli; folia caulina, superiora sessilia, inferiora rhomboidea-ovata subpetiolata; spica unilateris, pedunculata; pedicelli glabri vel basi pubescentes, ebracteolati; bracteae lineares, subintegres; corolla glabra, tubo 4.0-5.0 mm. longo, fisso; capsula ellipsoidali-fusiformis, supera, 1.5-2.5 mm. diam., 4.5-5.5 mm. longa.

This species connects this section of *Lobelia* with the genus *Diastatea;* it is arbitrarily separated from the latter by its perennial habit and its corolla-tube, which is cleft to a point 1.5 to 2.2 mm. from base. It has been confused with the small-flowered lobelias of the group centering around *L. Sartorii*, from which it is easily distinguished by its essentially superior ovary.

*Specimens examined:* OAXACA; mountain slopes near Tlaxiaco, *W. H. Camp 2205*, Dec. 16-19, 1936 (NY; TYPE).—CHIAPAS; near San Cristobal, *Nelson 3193* (GH,US).

20. *Lobelia homophylla* E. Wimm., Rep. Sp. Nov. 22:194. 1926.

*Lobelia Cliffortiana* var. *xalapensis* A. Gray, Syn. Fl. N. Am. ed. 2. **2**, pt. **1**:7. 1886, non *L. xalapensis* H. B. K.

This species is confined to peninsular Florida, extending north about to St. Johns County.

21. *Lobelia xalapensis* H.B.K., Nov. Gen. & Sp. 3:315 (folio ed. p. 246). 1819.

This species is widespread in tropical America, from Vera Cruz and Oaxaca

to Argentina; it is not found in the Greater Antilles, but occurs on Martinique and Dominica. It is easily distinguished from *L. Cliffortiana* and the other small-flowered species by its partially superior ovary and capsule and by its prickly or scabrous pedicels.

22. *Lobelia Cliffortiana* L., Sp. Pl. 931. 1753.

This was the first-described of any of the species of this section, and subsequent authors have referred to it various plants with ovate or cordate leaves and small bluish flowers, from all parts of tropical America. True *Lobelia Cliffortiana* is native only in Cuba, Hispaniola and Jamaica, but has occasionally been found as an introduction elsewhere. In the section *Hemipogon*, as in other sections of *Lobelia*, an interesting problem arises in connection with the taxonomy of the species of oceanic or other islands. *Lobelia Cliffortiana*, for example, differs from *L. xalapensis* by relatively minor characters, characters that would seem of little significance were the two species not kept absolutely segregated in geographical position. If the two plants, here called different species, grew in adjacent parts of the same continental area, we should expect to find a series of intermediates connecting them and it would seem logical to designate them as mere races of the same species. In the present setup, however, *all* the plants of the Greater Antilles are true *L. Cliffortiana*, and *all* the corresponding plants of the mainland are *L. xalapensis*, and there are *no* intermediates.

23. *Lobelia lucayana* Britt. & Millsp., Fl. Baham. 428. 1920.

Apparently endemic in the Bahamas; known only from Caicos and Watling's Islands.

24. *Lobelia yucatana* E. Wimm., Rep. Sp. Nov. 38:83. 1935.

Endemic in the lowlands of Yucatan and Peten, so far as known.

25. *Lobelia fastigiata* H.B.K., Nov. Gen. & Sp. 3:313 (folio ed. p. 244) 1819. *Lobelia trinitensis* Griseb., Fl. Brit. W. Ind. 385. 1861. *Lobelia Gardneriana* Kanitz, in Mart. Fl. Bras. **6**, pt. **4**:138. 1878.

Widely distributed in South America, south to Paraguay and southern Brazil. Occurs on Trinidad, but apparently not elsewhere in the West Indies. In North America known only from PANAMA: prov. Panama, between Matias Hernandez and Juan Diaz, *Standley 32038* (US).

26. *Lobelia Hartwegi* Benth., ex A.DC. in DC. Prodr. 7:361. 1839.

Oaxaca to the State of Mexico.

27. *Lobelia sinaloae* Sprague, Kew Bull. 1929: 7. 1929.

Simulating the preceding species in all its parts, but the flowers larger and the corolla-tube unique in being without a dorsal fissure. Endemic in western Mexico, being known only from Sinaloa.

28. *Lobelia fenestralis* Cav., Ic. 6:8. t. 512, f. 1. 1801.

This is a coarse and somewhat weedy species, easily recognized by its leafy

stems and rather dense spikes. It is common in the highlands of Mexico, ranging from Arizona and western Texas to Oaxaca.

29. *Lobelia poetica* E. Wimm., Rep. Sp. Nov. 22:195. 1926.

Known only from the TYPE, *Rose 2100* (US), collected "between Santa Gertrudis & Santa Teresa, Sierra Madre, Tepic." The calyx-lobes are sharply reflexed, even in the young flower, in this and the following species.

30. **Lobelia jaliscensis** sp. nov.

Herba perennis, simplex, radice carnoso, fusiforme; folia caulina, linearia vel anguste elliptica, apice basique acuta, subintegra, subtus glauca; capsula inferior; laciniae calycis valde reflexae; corolla extus pubescens, tubo 3.5 mm. longo, fenestrali; tubum antherarum apice barbatum, inclusum.

A species which has been confused with the following one. It is well characterized by its reflexed calyx-lobes and by its capsule, which is hemispheric and almost wholly inferior, with flattened base, in contrast to that of *L. irasuensis*, which is somewhat more than half inferior, ellipsoid or cupshaped, rounded or acute at base. It is known only from the type collection.

*Specimens examined:* "Open pine forest on steep hillside, San Sebastian, n.e. of Hacienda del Cura, Sierra Madre, 1425 m." (Jalisco), *Ynes Mexia 1371* (F, MICH, NY, US, USNA (TYPE)).

31. **Lobelia irasuensis** Pl. & Oerst. var. **irasuensis** nom. nov.

*Lobelia irasuensis* Pl. & Oerst., Kjoeb. Vidensk. Meddel. 153. 1857.
*Lobelia Warscewiczii* Vatke, Linnaea **38**:718. 1874.

This variety,the nomenclatorial type of the species, occurs on the high mountains of Costa Rica and western Panama. It seems to differ from the Mexican *Lobelia picta* Rob. & Seat. solely in the corolla, which in the latter is dark-veined, slightly larger than in the Central American plant, with the tube usually not fenestrate. These differences appear to be of nor more than varietal importance; plants with the corolla-tube lacking the fenestration occur in Panama, along with the normal form.

31a. **Lobelia irasuensis** Pl. & Oerst. var. **picta** (Rob. & Seat.) comb. nov.

*Lobelia picta* Rob. & Seat., Proc. Amer. Acad. **28**:112. 1893.

Apparently endemic in the state of Mexico, at altitudes of 3000 meters and above.

31b. **Lobelia irasuensis** Pl. & Oerst. var. **fucata** var. nov.

Corolla caerulea, venis purpureis, tubo fenestrali; semina laevia, nitida. A var. irasuensi venis purpureis, a var. picta tubo fenestrali, ambis seminibus nitidis differt.

This variety is apparently endemic in the State of Durango. The plants are characteristically taller than the other varieties of this species and somewhat more leafy.

*Specimens examined:* DURANGO; vicinity of the city of Durango, *Palmer 817* (F, GH (TYPE), NY, US); "State of Durango," *P. Ibana Garcia 471* (US).—MEXICO (state unknown); "N. W. Mexico," *Seemann* (GH).

32. *Lobelia umbellifera* McVaugh, Bull. Torr. Bot. Club 67:144. 1940.

*Lobelia fasciculata* Donn. Sm., 1899, *non* O. Ktze., 1891.

Endemic in Guatemala and adjacent Chiapas.

33. *Lobelia tarsophora* Seaton ex Greenman, Proc. Amer. Acad. 33:489. 1898.

This species is included in the present paper because of its rather doubtful position; it is superficially very like the plants of the group of *L. Sartorii,* but its seeds place it rather with the section *Eulobelia.* It is known only from the type collection (*Seaton 417,* from Cordoba, Vera Cruz (F, GH, NY)), and from Chapulhuacan, Hidalgo, *Lundell 7158* (F).

34. **Lobelia hypnodes** E. Wimm., *in herb.*, sp. nov.

*L. xalapensi* persimilis, a qua floribus majoribus, tubo corollae fenestrali, seminibus foveolatis differt. Ovarium superum; capsula 4.0 mm. longa; corollae tubus circa 5.0 mm. longus, dorso fissus ad basin.

Like the preceding, this species has the seeds of the section *Eulobelia,* but is included here because of its evident affinities with some of the species of *Hemipogon,* in particular with *L. xalapensis.* It is known only from the vicinity of Tantoyuca, Vera Cruz: *R. Cardenas 482,* Mar. 1910 (F, TYPE); *R. Cardenas 481* (US).

Examination of the type material and other important collections of the various species discussed in the present paper has been made possible through the continued kindness of those in charge of a number of herbaria, both in the United States and in Europe. It is the writer's pleasure to acknowledge the help and cooperation of these men. The herbaria in question are listed below. The abbreviations are those proposed by Lanjouw (Chronica Botanica 5:143-150. 1939), the only exception being that for the herbarium of the United States National Arboretum, which is not included in Lanjouw's list:

Botanisches Museum, Berlin, Germany (B); Universitetets Botaniske Museum, Copenhagen, Denmark (C); Field Museum, Chicago, Ill. (F); University of Georgia, Athens, Ga. (GA); Gray Herbarium, Harvard University, Cambridge, Mass. (GH); Royal Botanic Garden, Kew, England (K); University of California, Los Angeles (LA); University of Michigan, Ann Arbor (MICH); New York Botanical Garden, New York, N. Y. (NY); Oberlin College, Oberlin, Ohio (OB); Academy of Natural Sciences, Philadelphia, Penna. (PH); Pomona College, Claremont, Calif. (POM); Botanické oddel. Národního Musea, Praha, Czechoslovakia (PR); University of Texas, Austin, Tex. (TEX); U. S. National Herbarium, Smithsonian Institution, Washington, D.C. (US); U. S. National Arboretum, Washington, D. C. (USNA).

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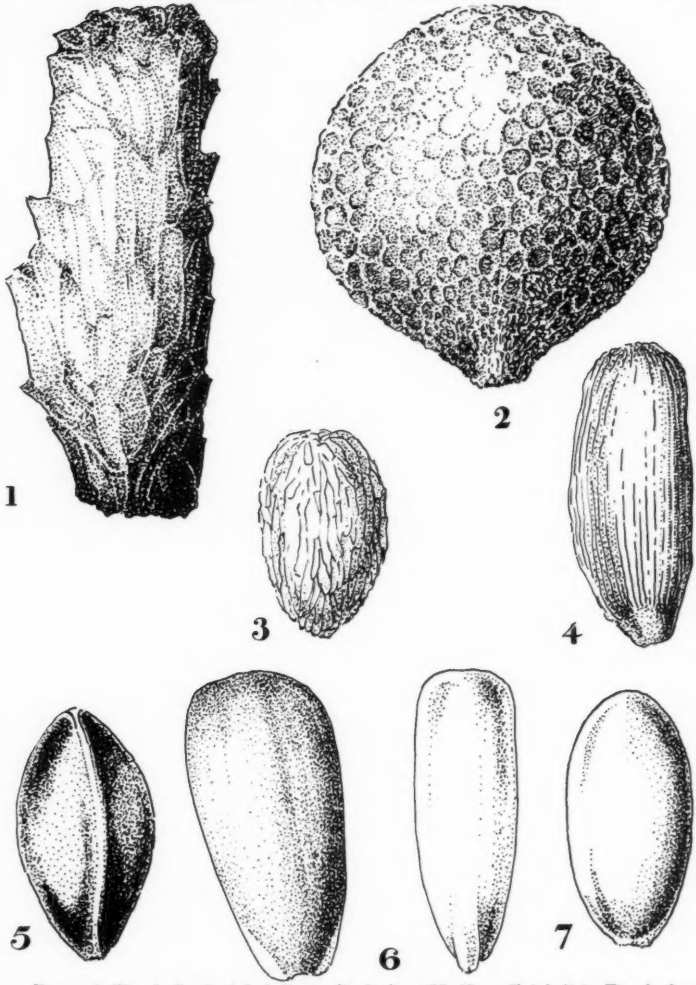


PLATE 1. Fig. 1. Seed of *Lobelia cardinalis* L., ×50 (Sect. Eulobelia). Fig. 2. Seed of *L. acuminata* Sw., ×50 (*Britton 1394*, Jamaica; Sect. Tylomium). Fig. 3. Seed of *L. Sartorii* Vatke, ×50 (*Pringle 3288*, San Luis Potosi; Sect. Hemipogon). Fig. 4. Seed of L. *laxiflora* H. B. K., ×50 (Sect. Homochilus). Fig. 5. Seed of *L. aquatica* Cham., ×50 (Sect. Holopogon). Fig. 6. Two views of seed of *L. anatina* E. Wimm., ×50 (Sect. Hemipogon). Fig. 7. Seed of *L. Dunnii* Greene, ×50 (Sect. Palmerella).

The writer acknowledges with gratitude the assistance of Mr. B. Y. Morrison of the Division of Plant Exploration and Introduction, who made the drawings reproduced in this plate.

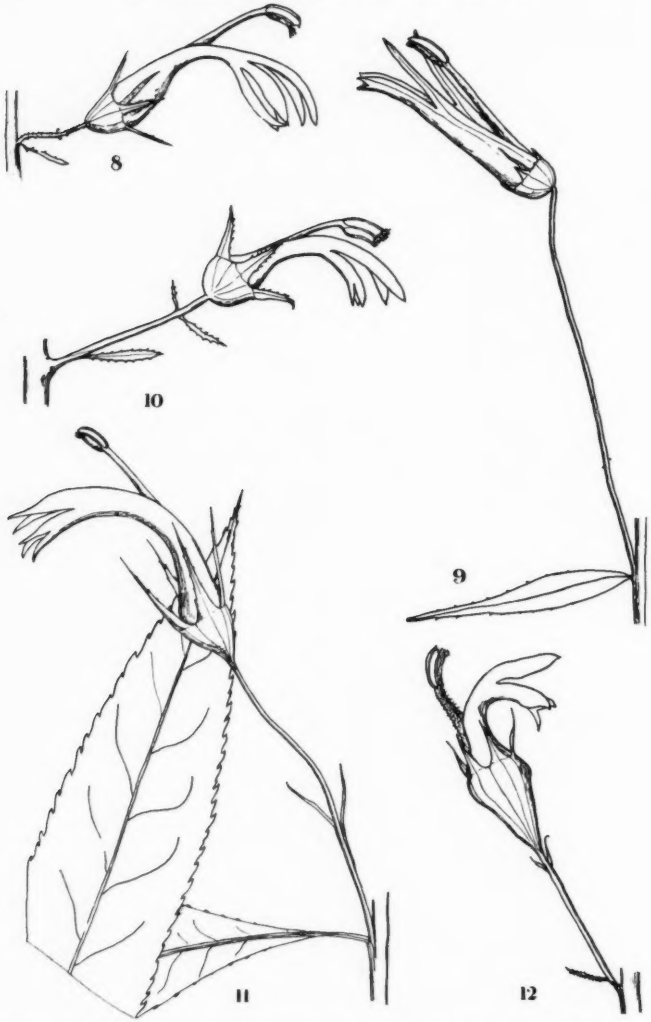


PLATE 2. Flowers of Lobelias, natural size. Fig. 8. *Lobelia rotundifolia* A. DC. (Sect. Eulobelia). Fig. 9. *L. laxiflora* var. *angustifolia* A.DC. (Sect. Homochilus). Fig. 10. *L. cirsifolia* Lam. (Sect. Tylomium). Fig. 11. *L. persicifolia* Lam. (Sect. Tylomium). Fig. 12. *L. innominata* Rendle (*Maxon & Killip 186*, Jamaica; Sect. Tylomium).

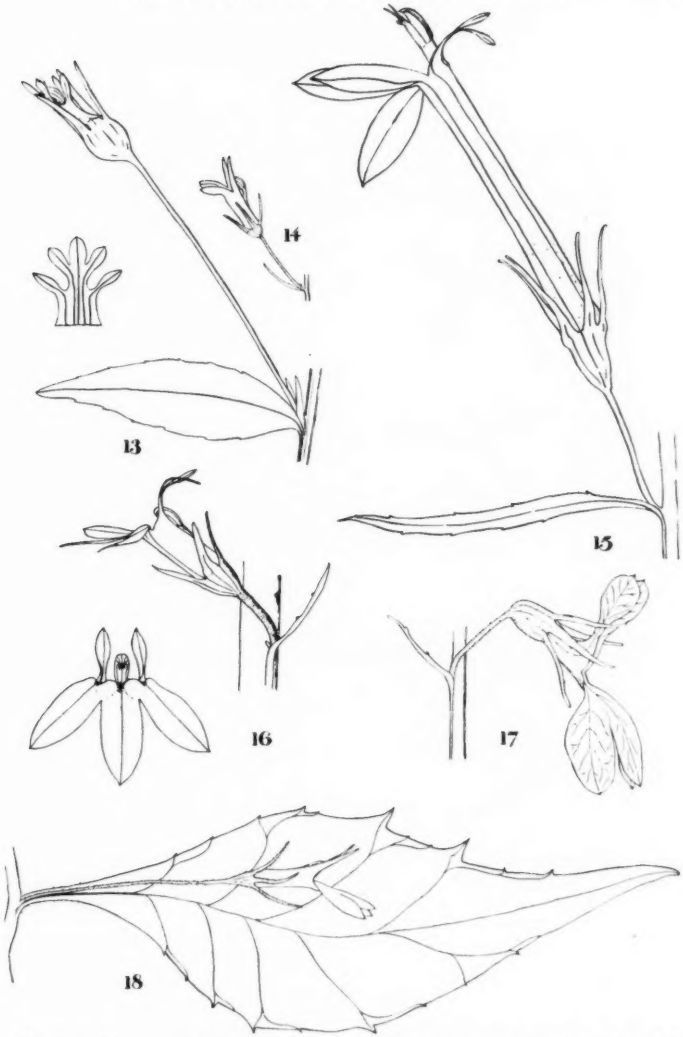


PLATE 3. Flowers of Lobelias, two and one-half times natural size. Fig. 13. *Lobelia aquatica* Cham. (Sect. Holopogon). Fig. 14. *L. xalapensis* H.B.K. (*Duss 1748*, Martinique; Sect. Hemipogon). Fig. 15. *L. Dunnii* Greene (*Wiggins & Demaree 4996*, Baja California; Sect. Palmerella). Fig. 16. *L. spicata* var. *originalis* McV. (Sect. Eulobelia). Fig. 17. *L. irasuensis* var. *picta* (Rob. & Seat.) McV. (Sect. Hemipogon). Fig. 18. *L. longicaulis* Brandg. (Sect. Hemipogon).

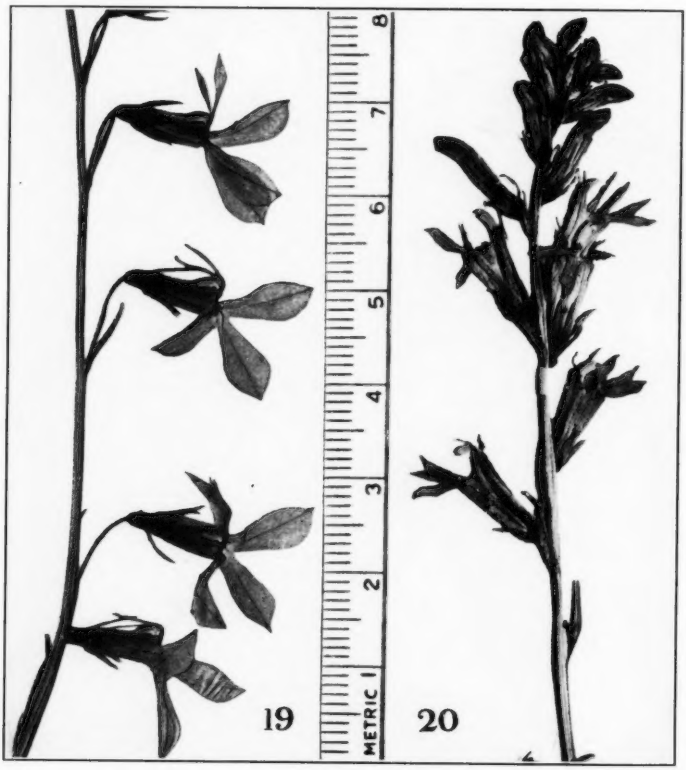


PLATE 4. Fig. 19. Inflorescence of *Lobelia anatina* E. Wimm. (from Chihuahua). Fig. 20. Inflorescence of *L. gruina* Cav. (from the State of Mexico).

# Oaks of Trans-Pecos Texas

Cornelius H. Muller

The identification of the species of *Quercus* in western Texas has long been an exceedingly difficult procedure, yielding for the most part unsatisfactory results. Sargent (Man. Trees N. Amer. 2nd ed. 1922) included no shrubby forms, and his treatment is now outmoded by the recent description of several new species. Trelease (Mem. Nat. Acad. Sci. 20. 1924) included no complete key to the species and treated without descriptions several of the older species of western Texas. His treament is also somewhat outmoded by the recent additions to the oak flora. Partial lists, covering only the region of the Chisos Mountains, by Sperry (Sul Ross S. T. Coll. Bull. 19. 1938) and Muller (Trans. Tex. Acad. Sci. 20. 1937) merely enumerate the species. The entire oak flora of this area has not been treated as a group since Coulter's Botany of Western Texas (Contr. U. S. Nat. Herb. 2) was published in 1894. The inclusion of several hundred other species makes difficult the use of Trelease's monograph. There seems to be a definite need for a clarification of the positions and identities of the new species recently described amongst the Texas oaks, as well as some of the older ones which have never been clearly understood. Since the species of *Quercus* lend themselves poorly to description, a new species seldom can be established amongst botanists in general until it has been included in a key to all the species of its area accompanied by adequate illustrations.

It is hoped that the accompanying key, descriptions, and illustrations will aid the non-specialized botanist to identify with a minimum of labor any species of oak in western Texas. Real difficulty has been encountered in constructing a workable key to the species. Several species clearly different to the specialist appear indistinct to others, and many characters necessary to the distinction of some species are often obscured in incomplete or immature material. Some characters do not lend themselves to ready expression either verbally or written. A real effort has been made to choose the most outstanding and less technical differences and to express them as clearly as possible.

Hybridism has been widely ascribed to the oaks. Although some several instances of indubitable hybridism have been described, the author has seen no example in western Texas which he would admit to that category. Extreme variation is the rule in oak species, and usually this variation makes difficult, if not impossible, the task of accurately identifying closely related species. In some cases the fault lies in the inadequacy of treatment of such species. In others the species are too closely related and should not be distinguished. In many cases, however, the student attempting the identification has insufficient familiarity with his material or insufficient material available, or he simply does not care to give the subject the necessary painstaking study. It is often much easier to dismiss an apparent intermediate with a shrug of the shoulders and a

derogatory remark concerning its probable hybrid ancestry. In most such cases a careful study of a wide range of material reveals the fact that the apparently intermediate specimen is merely an extreme form of one of the suspected species. In a few instances such "intermediates" prove to be distinct species, either new to science or not previously known to occur in that locality. There is no escape from the fact that the taxonomy of oaks requires much more study than does that of most groups of plants.

Eighteen species are recognized in the area comprised roughly of that part of Texas lying west of the Pecos River and the few adjacent counties to the east. The species of the plains area in the Panhandle of Texas are not included.

## QUERCUS L.

Trees or shrubs with alternate, simple, petioled leaves, blades entire, toothed, or lobed, persistent or deciduous; stipules associated with the buds, ligulate, often early caducous; flowers monoecious, the staminate in flaccidly pendulous aments, consisting of an undifferentiated, (about) 5-lobed perianth and 5 to 10 free stamens; the pistillate solitary or grouped, subsessile or pedunculed, consisting of a 3-carpellate ovary (1-celled and containing 6 ovules) inferior to the 6 lobes of the perianth, bearing 3 short styles, and enclosed in an involucre of numerous flat scales; fruit a nut (acorn), 1-seeded, the 5 remaining ovules aborted, enclosed (at least at the base) in a cup (involucre) of flat or basally thickened scales, maturing in 1 or 2 seasons.

### KEY TO SPECIES

A. Fruit not tomentose within the shell, abortive ovules basal; cup scales much thickened basally, the apices narrowed; stigmas short and broad; leaves if toothed not aristate by projection of the veins (sometimes apparently so but only mucronate); bark commonly gray and scaly or flaky.....
.....White Oaks—LEUCOBALANUS

B. Leaves manifestly lobed.

C. Lobes not acute or mucronate or if so, then leaves loosely stellate-hairy or or glabrate, leaves usually 8 cm. long or longer.....7. *Q. Gambelii.*

CC. Lobes acute and mucronate, leaves very scabrous, less than 5 cm. long, margins markedly crisped.....5. *Q. pungens.*

BB. Leaves entire, toothed, or very shallowly lobed.

D. Leaves crenately lobed or undulate with numerous short mucronate or blunt lobes and shallow rounded sinuses, usually 10 cm. long or more, lateral veins numerous and strikingly parallel.....8. *Q. Brayi.*

DD. Leaves variously toothed or entire but not as above, the veins less than ten on each side and not strikingly parallel.

E. Leaves scabrous, margins crisped .....5. *Q. pungens.*

EE. Leaves soft-pubescent or glabrate, margins flat or scarcely undulate.

F. Leaves small (1.5 to 3 cm. long), broadly ovate, toothed all around with spinose tips 1 to 1.5 mm. long.....9. *Q. turbinella.*

FF. Leaves small or large but if small then entire or with few teeth and these mucronate, the tips not spinose and 0.5 mm. long or shorter.

G. Leaves obovate in outline, the broadly rounded apical end with several mucronate projections, veins impressed above and strik-

ingly prominent to the ultimate reticulum beneath....3.*Q. diversicolor.*

GG. Leaves if obovate not broadly rounded above nor with several mucronae, the veins moderately if at all prominent beneath.

H. Leaves apparently glabrate beneath or densely pubescent with minute white stellate hairs closely appressed (appearing a glabrous white surface under a weak lens), in no case with spreading hairs beneath.

I. Leaves markedly white beneath due to minute appressed stellate hairs, entire or few-toothed, veins raised above but scarcely discernible beneath; cups obconic with an attenuate scaly base, markedly pedunculate.....10. *Q. fusiformis.*

II. Leaves moderately appressed-stellate beneath or nearly glabrate, margins markedly toothed throughout, veins quite prominent beneath; cups hemispheric, subsessile or short-stalked. .....6. *Q. Vaseyana.*

HH. Leaves variously spreading-pubescent beneath, if apparently glabrate then not markedly toothed.

J. Leaves markedly white or gray beneath due to short spreading stellate hairs, dark green and shiny above..2. *Q. Mohriana.*

JJ. Leaves green or tawny beneath.

K. Veins markedly impressed above, leaves densely tawny-tomentose beneath; low dense shrubs with leaves usually less than 2.5 cm. long.....4. *Q. intricata.*

KK. Veins not impressed above, leaves loosely tomentose beneath; trees or openly branched erect shrubs with leaves over 3 cm. long .....1. *Q. grisea.*

AA. Fruit tomentose within the shell, abortive ovules lateral or apical; cup scales thin and flat; stigmas elongated-spatulate; leaves if toothed or lobed markedly aristate by projections of the veins; bark commonly black and deeply furrowed, hard, and not scaly or flaking .....Black Oaks—ERYTHROBALANUS.

L. Veins impressed above, leaves glaucous-green above especially when dried, lanceolate or oblanceolate, densely or sparsely tomentose beneath, evergreen.

M. Leaves usually narrowly lanceolate, entire or with a few low teeth, densely white tomentose beneath.....13. *Q. hypoleucoides.*

MM. Leaves broadly oblanceolate to narrowly obovate, deeply several-toothed above the middle, sparingly hairy with very short stellate hairs so as to appear glabrate with age .....14. *Q. livermorensis.*

LL. Veins not impressed above, leaves bluish- to yellowish-green above, never glaucous, if lanceolate, then not markedly pubescent beneath.

N. Leaves hastate to lanceolate, entire or toothed, nearly glabrous save for a tuft of tawny stellate hairs on each side of the base of the midrib beneath, deciduous; fruit annual.....11. *Q. Emoryi.*

NN. Leaves lanceolate to ovate, variously pubescent or glabrous but not as described above, evergreen or deciduous; fruit biennial.

O. Leaves evergreen, densely loose-tomentose when young, becoming glabrate above and detachably tomentose beneath at maturity ..... .....18. *Q. tardifolia.*

OO. Leaves deciduous (?), glabrous or closely stellate-pubescent, never loosely tomentose.

P. Leaves narrowly lanceolate or oblanceolate.

Q. Petioles 5 to 7 mm. long; leaves characteristically oblanceolate with short apices acute.....12. *Q. Tharpii.*

QQ. Petioles 15 to 20 mm. long; leaves narrowly lanceolate, the apices long attenuate.

R. Leaves with several aristate lobes on each side....15. *Q. graciliformis.*

RR. Leaves entire or with 2 or 3 lobes near the apex.....15a. *Q. graciliformis* f. *parvilobata.*

PP. Leaves broadly lanceolate to ovate.

S. Leaves persistently stellate-pubescent above, stiff and coriaceous; acorns cylindric; twigs stiff and heavy.....17. *Q. robusta.*

SS. Leaves glabrous above, thin and of soft texture; acorns ovoid to subconic; twigs slender and flexible.....16. *Q. Gravesii.*

## LEUCOBALANUS. White Oaks

### 1. *Quercus grisea* Liebmann, Overs. Dansk. Vidensk. Selsk. Forhandl. 1854:171. 1854

*Q. undulata* var. *grisea* Engelmann, Trans. St. Louis Acad. **3**:393. 1877.

Twigs 2 mm. in diameter, scarcely fluted, shortly yellow-tomentose, dark gray and somewhat hoary for several years. Buds reddish-brown, rounded, the outer scales puberulent, scarcely 2 mm. in diameter. Leaves deciduous, elliptical to ovate, entire or occasionally toothed above, mucronately subacute, rounded or slightly cordate, 3 (rarely 1.5 or 5) cm. long, 1.5 (or 1 to 3) cm. broad, coriaceous but thin, dull blue-green and minutely stellate above or polished if rubbed, stellate-scurfy beneath; veins about 8 pairs; petioles about 5 mm. long. Fruit annual, paired at the end of a tomentose peduncle about 1 x 10 to 15 mm.; cups shallowly turbinate, about 10 mm. in diameter, with thin appressed rather acute canescent scales; acorns ellipsoid, about 12 mm. long and 8 mm. in diameter, about one-third included. (See Fig. 1).

*Q. grisea* ranges from Coahuila and Chihuahua, through western Texas (middle and upper atlitudes of all the major mountain ranges), to New Mexico and eastern Arizona. The type was collected in Texas. The species occurs as a low tree or a shrub and forms extensive forests with *Pinus edulis* and *Juniperus* spp. in the altitude zone between 5,000 and 7,500 feet.

*Q. grisea* and its relative *Q. intricata* belong to a motley group of shrubby oaks centering in Mexico which have no other close relatives in the United States except the more westerly *Q. arizonica* Sarg. The latter species is distinguished by its leaves prominently reticulate-veiny beneath and the veins somewhat impressed above.

*Q. endemica* C. H. Mull. (Amer. Midl. Nat. 18:846. 1937) was thought to occur in the Chisos Mountains of western Texas. It now seems unlikely that the Texas material belongs to this Coahuilan species, and rather that the Texas plant is a shade form of *Q. grisea* and only superficially resembles the Mexican species. *Q. endemica* shows affinity to *Q. clivocola* Trel. & Mull. of Nuevo Leon.

Fig. 1. *Quercus grisea* Liebm. Fig. 2. *Quercus Mohriana* Buckl.

2. *Quercus Mohriana* Buckley in Rydberg, Bull. N. Y. Bot. Gard. 2:219. *pl. 31.* 1901—exclusive of the Mexican material

Twigs 1.5 to 2 mm. thick, scarcely fluted, densely tomentose with short yellowish stellate hairs, scurfy the second year, becoming gray with a few scarcely evident lenticels. Buds round or ovoid, 1 to 1.5 mm. in diameter, reddish-brown, scurfy; stipules caducous. Leaves deciduous, 2 to 5 cm. long, 0.8 to 1.5 or rarely 2.5 cm. broad, oblong, rounded to subcordate or rarely subcuneate at base, the apex mucronate, obtuse or acute, entire or crenately low-toothed, upper surface shiny dark green or dull, sparsely stellate-scurfy or glabrate, lower surface persistently creamy- or white-stellate-tomentose, the tomentum compact and appressed but obvious even without a lens; veins 6 or 8 on each side, much branched and looping, slightly if at all raised above (the reticulum as much as the pinnae), prominent beneath; petioles 2 to 5 mm. long, densely stellate. Fruit annual, solitary or paired, subsessile or short-stalked; cups hemispheric, 12 to 15 mm. wide, the scales much thickened basally, canescent; acorns narrowly ovoid, about 15 mm. long and 10 or 12 mm. broad, one-third or more included. (See Fig. 2).

This species occurs as a low shrub or a small tree. The type locality is Devils River in western Texas, and the species ranges north to the "breaks" of the Great Plains as far as Armstrong County and south along the east face of the mountains of Coahuila. No doubt it may also be found on both sides of the Pecos River.

The strong contrast in color between the upper and lower surfaces of its leaves sets *Q. Mohriana* off from *Q. grisea* whose leaves are nearly equally green (or gray-hairy) on both surfaces. *Q. Mohriana* is often confused with *Q. Vaseyana* whose leaves are often whitened beneath by minute, closely appressed, stellate hairs as opposed to the clearly (but inconspicuously) spreading pubescence of *Q. Mohriana.*

3. *Quercus diversicolor* Trelease, Mem.. Nat. Acad. Sci. 20:73. 1924

*Q. reticulata* Engelmann, Trans. St. Louis Acad. **3**:383. 1876. Not *Q. reticulata* Humboldt and Bonpland, Pl. Aequinoct. **2**:40. *pl. 86.* 1809.

Twigs 2 to 3 mm. in diameter, fluted, from stellate-pilose glabrescent, rather glossy brown with inconspicuous small lenticels. Leaves evergreen or occasionally deciduous, round-obovate, shallowly cordate, low-dentate or mucronate above, 4 to 6 cm. long, 3 to 4 cm. wide, convex above or flat, the upper surface slightly glossy green and sparingly stellate-pubescent, the lower surface dull, loosely hairy, and brownish-yellow-granular or occasionally not; veins about 8 pairs, impressed above, very prominent beneath even to the ultimate reticulum, somewhat forked but not looping; petioles stellate-hairy, about 1 x 5 mm. Staminate catkins about 50 mm. long, rather loosely flowered, fleecy, the smooth rounded anthers little exserted. Fruit annual, 2 or 3 at the end of a slightly hairy peduncle about 10 to 15 mm. long or longer and 2 mm. thick; cups hemispheric, 10 to 15 mm. in diameter, with thin closely appressed acute brown scales somewhat rusty or canescent below; acorns ovoid, about 10 mm. long, nearly half included. (See Fig. 3).

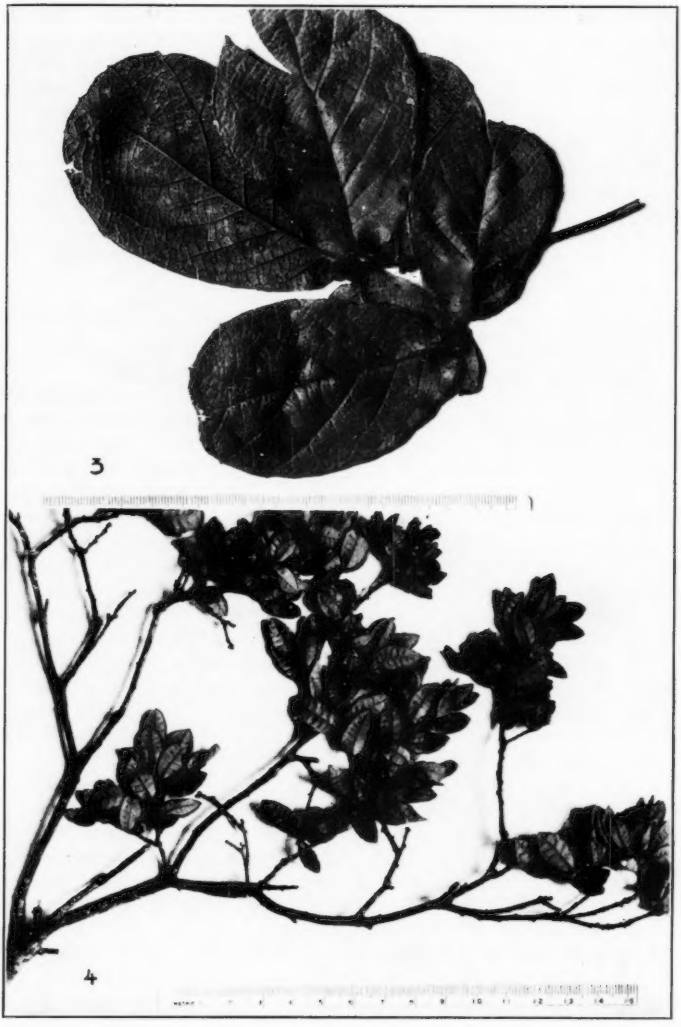


Fig. 3. *Quercus diversicolor* Trel. Fig. 4. *Quercus intricata* Trel.

The type of this species came from the mountains of Chihuahua where it occurs as a small tree. It ranges through the mountains of northern Coahuila, western Texas (Chisos and Davis Mts.), southern New Mexico, and Arizona. In some localities, notably in New Mexico, the species occurs only as a shrub. Throughout its range this oak is very variable in leaf form and leaf size. Flat and convex, large and small, broad and narrow forms occur at random and have no taxonomic significance.

*Q. diversicolor* is closely related to *Q. reticulata* Humb. & Bonpl. in central Mexico and further study may show this to be only a variety of that species. There are no related species within our area.

4. *Quercus intricata* Trelease in Standley, Contr. U. S. Nat. Herb. 23:185. 1922

*Q. microphylla crispata* A. de Candolle, Prodr. **16**:36. 1864. Not *Q. crispata* Steven, Bull. Soc. Imp. Nat. Moscou **30**:386. 1857.

Twigs short, slender (1 to 2 mm.), scarcely fluted, densely short-dingy-tomentose. Buds brown, glabrescent, ovoid, scarcely 2 x 3 mm. Leaves deciduous, subelliptical, round-ovate, or narrowly oblong, typically acute, cordate, entire or crenately toothed, markedly revolute, crisped, 1 to 1.5 or rarely 3 or 5 cm. long, 0.5 to rarely 1 or 2 cm. broad, dull, stellate-scurfy above, densely gray- or yellowish-tomentose beneath; veins about 6 pairs, very indistinct; petioles tomentose, 1 x 2 to 3 mm. Staminate catkins 5 to 10 mm. long, lanate, densely flowered, or 20 to 30 mm. long and loosely flowered, the glabrous rounded anthers scarcely exserted. Pistillate catkins 5 mm. long, about 2-flowered at the end. Fruit annual, nearly sessile; cups hemispheric, 10 mm. in diameter, with thin appressed acute scales very tomentose below but glabrescent and red at the tips; acorns rounded, two-thirds or more included. (See Fig. 4).

This species was described from southern Coahuila and Zacatecas whence it ranges north and west throughout the isolated mountain ranges of Coahuila to western Texas (Chisos and Davis Mts.). It is a low and densely branched shrub seldom reaching a height of more than 1 m., and it forms dense thickets on open, xeric slopes at altitudes ranging about 6,500 feet.

*Q. intricata* is a species of uncertain relationships centering in the complex group of shrubby species of northeastern and northcentral Mexico. It has no close relatives in the United States flora. Although Trelease's name for this species was first published in 1922 as cited above, in his monograph (Mem. Nat. Acad. Sci. 20:84. 1924) he treats the name as having been published there for the first time.

5. *Quercus pungens* Liebmann, Overs. Dansk. Vidensk. Selsk. Forhandl. 1854:171. 1854. Not *Q. pungens* Gandoger, Fl. Eur. 21:41. 1890

*Q. undulata* var. *Wrightii* Engelmann, Trans. St. Louis Acad. **3**:382. 1876.
*Q. undulata* var. *pungens* Engelmann, Trans. St. Louis Acad. **3**:392. 1877.

Twigs 1 to 1.5 mm. thick, subterete, densely yellowish-stellate-tomentose and persistently somewhat scurfy, becoming gray with few inconspicuous

Fig. 5. *Quercus pungens* Liebm. Fig. 6. *Quercus Vaseyana* Buckl.

lenticels. Buds round or ovoid, about 1.5 mm. long, the scales reddish-brown and scurfy; stipules caducous. Leaves evergreen, 2 to 4 cm. long, 1.5 to 2.5 cm. broad, ovate to obovate in outline, acute, basally rounded to distinctly cordate, 3- to 5-toothed on each side, the teeth shortly spine-tipped, margins deeply undulate-crisped (the vertical undulations usually equal to the horizontal width of the sinuses), upper surface shiny, sparsely spreading-stellate with harsh yellow hairs (giving the feeling of sandpaper), lower surface densely covered with two types of pubescence, appressed silky simple or closely appressed stellate hairs covering the entire surface and scattered harsh stellate spreading hairs making the surface scabrous; veins 4 or 5 on each side passing into the teeth and with an occasional intermediate, all more or less branching but scarcely looping, veins and reticulum somewhat raised on both surfaces; petioles 2 to 3 mm. long, densely yellow-stellate-tomentose. Fruit annual, solitary or paired, subsessile or very short-stalked; cups hemispheric, about 8 or 10 mm. in diameter, the scales canescent and markedly thickened basally; acorns ovate, 10 or 12 mm. long, about 6 or 8 mm. broad, about one-third included. (See Fig. 5).

This species is a low shrub occurring on open, rocky slopes at lower altitudes. The species is most closely related to *Q. Vaseyana* whose relationship is discussed below. The leaves of *Q. pungens* are occasionally not constant in their crispedness. In western Coahuila there occurs a population typical in every respect except for the lack of crisped leaf margins. Occasionally individuals of this population have been exposed to severe desiccation and heavy browsing by goats, and such plants produce an abundance of typically crisped leaves.

*Q. pungens* was first described from the vicinity of El Paso, Texas, and it ranges east to the lower slopes of the Guadalupe Mountains, west and north to Arizona and central New Mexico, and south into Chihuahua and Coahuila.

6. *Quercus Vaseyana* Buckley, Bull. Torr. Bot. Club 10:91. 1883

*Q. undulata Vaseyana* Rydberg, Bull. N. Y. Bot. Gard. 2:218. 1901.

Twigs 1 to 1.5 mm. thick, glabrous and reddish-brown on vigorous shoots or yellow-stellate, markedly fluted, becoming gray with few inconspicuous lenticels. Buds round or ovoid, 1 to 1.5 mm. long, scales dark reddish-brown, slightly scurfy; stipules caducous. Leaves deciduous (?), 2.5 to 4 or rarely 6 cm. long, 0.6 to 1.5 or even 2 cm. broad, narrowly ovate to oblong or distinctly lanceolate, apex acute or mucronately obtuse, base cuneate, rounded, or rarely subcordate, margins markedly (sometimes distantly) toothed throughout, flat or somewhat crisped, upper surface glabrous and shiny or sparsely stellate-scurfy near the base of the midrib, lower surface densely or sparsely minute-appressed-stellate, never spreading-hairy, sometimes nearly glabrous, the naked surface shining; veins 3 or 4 on each side passing into the teeth and with one or two branching intermediates, prominently raised even to the reticulum on both sides, the principal veins and intermediates beneath glabrous and drying reddish-orange against the canescent lower leaf; petioles 2 to 4 mm. long, upper surfaces stellate-scurfy. Fruit annual, solitary paired or in threes, subsessile or

short-stalked; cups hemispheric or deeper, 7 to 9 or rarely 11 mm. wide, the scales scurfy, markedly tumid below, the apices flat and narrowly subacute; acorns ovoid to usually narrowly elliptic or cylindric-oblong, about 10 mm. long, 5 to rarely 8 mm. broad, glabrous, one-fourth to occasionally one-half included. (See Fig. 6).

*Q. Vaseyana* is a shrub or small tree occurring scattered on rocky slopes at low altitudes. The species is most closely related to *Q. pungens* which it markedly resembles and from which it is very difficult to distinguish. The only slightly crisped leaves and the minutely appressed pubescence (lack of spreading and of scabrous hairs) best separate *Q. Vaseyana* from *Q. pungens*.

*Q. Vaseyana* was first collected along the Devils River in western Texas. It ranges west to the Chisos mountains and probably somewhat farther, east as far as Uvalde County, and probably up to the Pecos River toward the New Mexican boundary. In Mexico it ranges through Coahuila, Nuevo Leon, and Tamaulipas along the east face of the mountains. Trelease erroneously states the type locality of this species to be the same as that of *Q. undulata* Torr. in Colorado. Rydberg's reduction of *Q. Vaseyana* to subspecific rank under *Q. undulata* is totally beyond comprehension since the species is much more closely related to *Q. pungens* whose range falls between those of *Q. Vaseyana* and *Q. undulata*.

7. *Quercus Gambelii* Nuttall, Journ. Acad. Philadelphia n. s. 1:179. 1848

*Q. Douglasii Gambelii* A. de Candolle, Prodr. **16**:23. 1864.
*Q. undulata obtusifolia* A. de Candolle, Prodr. **16**:23. 1864.
*Q. undulata Gambelii* Engelmann, Trans. St. Louis Acad. **3**:382, 392. 1876-77.
*Q. obtusifolia* Rydberg, Bull. N. Y. Bot. Gard. **2**:213. *pl. 29*. 1901.
*Q. Marshii* C. H. Muller, Amer. Midl. Nat. **18**:848. 1937.

Twigs 1 to 2 mm. thick, markedly fluted, stellate-scurfy, light brown and with a few rather conspicuous lenticels, becoming glabrate and gray with the lenticels less salient. Buds ovoid, subacute, about 3 mm. long and 2 mm. broad, scales light brown and scurfy or only ciliate; stipules caducous. Leaves deciduous, 4 to 8 cm. long (or individuals rarely only 2 cm.), 2 to 6 cm. broad, obovate to narrowly elliptic, obtuse, basally cuneate or sometimes unequally rounded, deeply 4- or 5-lobed on each side, the lobes rounded, rarely mucronate, longer than broad, the sinuses narrow, rounded, and reaching usually two-thirds or three-fourths the distance to the midrib (some rare plants with small subentire or very shallowly lobed leaves can be identified as this species only by familiarity with the specific range of variation), upper surface dark green, dully shining, sprinkled with exceedingly fine short stellate hairs or rarely glabrate, lower surface light green, dull, copiously sprinkled with soft velvety stellate hairs or rarely nearly glabrate; veins as many as the lobes, distinctly raised (including the reticulum) on both surfaces; petioles 5 to 10 or rarely 15 mm. long, densely stellate or somewhat glabrate. Fruit annual, solitary paired or clustered, subsessile or very short-stalked in Texas material; cups hemispheric or shallower, 10 to 12 or 14 mm. in diameter, the scales prominently thickened and scurfy at base, the rounded apices thin and closely appressed; acorns ovoid

or subrotund, 12 or more mm. long, 10 or 12 mm. broad, light brown, glabrate except for the silky sunken base, one-half or more included. (See Fig. 7).

*Quercus Gambelii* occurs as a low shrub or a small tree on the upper slopes of the Chisos, Davis, and Guadalupe Mountains in Texas; in more northern latitudes it descends to the plains. The deeply lobed broad leaves of this species readily set it off from any other species of western Texas.

This species was first described from the vicinity of Santa Fe, New Mexico. It ranges from South Dakota through Wyoming to Nevada, Arizona, and northern Chihuahua, and through Colorado to Texas and northwestern Coahuila. Numerous attempts have been made to divide the multitudinous forms, but few of them really deserve specific rank. The Texas and Coahuila material now seems particularly ill adapted to specific segregation, but a few of the New Mexico, Colorado, and Chihuahua forms eventually must be recognized.

8. *Quercus Brayi* Small, Bull. Torr. Bot. Club 28:558. 1901

*Q. Muehlenbergii Brayi* Sargent, Bot. Gaz. **65**:442. 1918.
*Q. Muehlenbergii* of authors—as to western Texas and New Mexico. Not *Q. Muehlenbergii* Engelmann, Trans. St. Louis Acad. **3**:391. 1877.

Twigs 1 to 2 mm. thick, markedly fluted, glabrous or somewhat scurfy, light brown with prominent light lenticels, becoming gray or reddish-brown with a gray bloom in age. Buds ovoid, obtuse, scarcely more than 2 mm. long, scales light brown, ciliate; stipules subulate, caducous. Leaves deciduous, 8 to 16 or sometimes only 5 cm. long, 4 to 10 or sometimes only 2 cm. broad, obovate to ovate or narrowly elliptic, grossly acute with a rounded mucronate-tipped terminal lobe, the bases unequally rounded to subcuneate or subcordate, the margins minutely revolute or nearly flat, crenately shallow-lobed or toothed, the teeth rounded or rarely mucronate-acute, 7 to 10 on each side, upper surface dark green, dully shining, sparsely minutely stellate-scurfy or glabrate, lower surface light green or canescent, sparsely or densely minute-appressed-stellate; veins as many as the teeth and passing into them, raised on both surfaces (including the reticulum) but prominently so beneath, principal and secondary ones glabrous against the canescent lower surface; petioles 10 to 20 or 25 mm. long, glabrous or stellate-scurfy, especially above. Fruit annual, solitary paired or in groups of three, subsessile short-stalked or on peduncles up to 2.5 cm. long; cups hemispheric to deeply saucer-shaped, 15 to sometimes 20 mm. in diameter, the scales roundly thickened and canescent basally, the rounded apices thin and closely appressed; acorns round-ovoid, about 15 to 20 mm. long, 10 to 15 mm. broad, about one-third included. (See Fig. 8).

*Q. Brayi* occurs as a small tree in densely shaded moist canyons in the higher mountains. It is known in western Texas from the Chisos, Davis, and Guadalupe Mountains. This species is a problematic one. The type was collected near Kertville, Texas, where *Q. Muehlenbergii* also occurs. The western Texas form reaches southern New Mexico in the Guadalupe Mountains and vicinity and ranges south through the mountains of Coahuila and Nuevo Leon, a range which is completely isolated from the Edwards Plateau

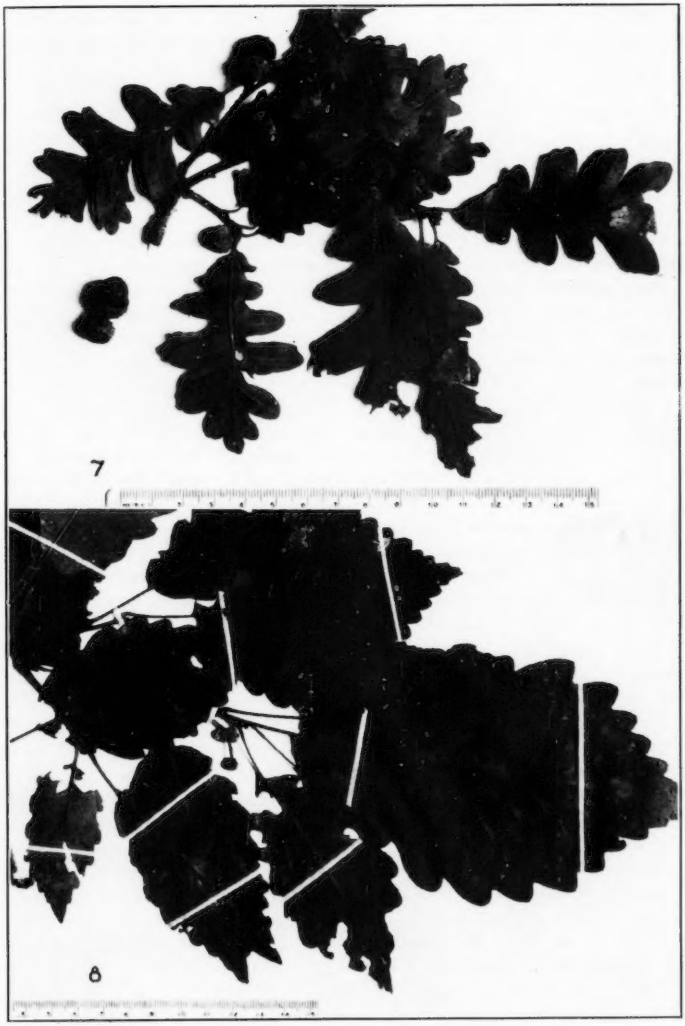


Fig. 7. *Quercus Gambelii* Nutt. Fig. 8. *Quercus Brayi* Small.

population of questionably distinct *Q. Brayi* and *Q. Muehlenbergii*. The western form is distinguished from the latter species by its relatively broader leaves. From all other species in western Texas it is readily separated by its shallowly crenately many-toothed leaves.

9. *Quercus turbinella* Greene, Ill. West. Am. Oaks 37. *pl.* 27. 1889

*Q. dumosa turbinella* Jepson, Silva Calif. 218. 1910.
*Q. subturbinella* Trelease, Mem. Nat. Acad. Sci. **20**:95. *pl. 153.* 1924.
*Q. pungens* of authors—as to New Mexico and Arizona. Not *Q. pungens* Liebmann, Overs. Dansk. Vidensk. Selsk. Forhandl. **1854**:171. 1854.

Twigs about 1 mm. thick, slightly fluted or terete, densely yellowish-stellate becoming persistently scurfy and reddish- or grayish-brown with few scarcely evident lenticels. Buds round to ovoid, 1 to 1.5 mm. in diameter, scales reddish-brown, ciliate and slightly scurfy; stipules caducous or rarely persistent. Leaves deciduous, 1.5 to 3 cm. long, 0.8 to 1.8 cm. broad, ovate, elliptic, or rarely oblong, apex rounded in outline or nearly acute, rounded to subcordate at the base, aristately 3- to 5-dentate on each side with low teeth, the aristae (including that of the apex) 1 to 1.5 mm. long, margins flat or scarcely undulate-crisped, upper surface sparsely sprinkled with minute yellow stellate hairs, shiny, lower surface similarly pubescent with simple or stellate hairs, dull, often yellowed by minute resinous exudations; veins about 4 or 5 on each side, somewhat prominent on both surfaces, the fine reticulum raised on both surfaces; petioles 2 to 3 mm. long, densely yellow-stellate-tomentose. Fruit annual, solitary to several clustered or dispersed on a scurfy peduncle 1 to 4 cm. long; cups hemispheric or deeper, 8 to 10 mm. in diameter, with scurfy basally thickened scales having broad obtuse thin apices; acorns ovoid to narrow-ovoid, silky, one-third to one-half included. (See Fig. 9).

This species is a low shrub or rarely tree-like. It occurs usually as a constituent of chaparral zones on low mountain slopes. The plant has often been confused with *Q. pungens* from which it is readily distinguished by its nearly flat leaves with elongate spinose tips on the teeth and apex. It is closest related to *Q. dumosa* Nutt., and from that species it is distinguished by its small cups with relatively flat scales as well as its spinose leaf tips.

The type of *Q. turbinella* was collected in southern California, but its center of distribution lies in Arizona and New Mexico. The latter population seemed to Trelease distinct from the southern California plant and was called by him *Q. subturbinella*. As now understood the southern California plant represents an unstable intergrading population tending toward *Q. dumosa* but still representative of *Q. turbinella*. This is by no means the first case of a strikingly different species being first described from atypical and confusing material near the edge of its range.

This species is known also in Nevada and Colorado. It is here recorded for the first time in Texas on the basis of a collection in the U. S. National Herbarium (sheet no. 1,583,650) by R. S. Kellogg which bears the collector's field data as follows: "Quercus undulata Torr. variety with small leaves (forma pungens). Western Texas, Aug. 1902." Unfortunately no specific locality is

Fig. 9. *Quercus turbinella* Greene. Fig. 10. *Quercus fusiformis* Small.

given, but it is very likely that the plant comes from the Franklin Mountains or some other relatively minor range near El Paso.

10. *Quercus fusiformis* Small, Bull. Torr. Bot. Club 28:357. 1901

*Q. virginiana fusiformis* Sargent, Bot. Gaz. **65**:448. 1918.

Twigs about 2 mm. in diameter, little fluted, minutely but densely grayish-tomentose. Buds reddish, velvety, rounded, 1 mm. in diameter. Leaves evergreen, narrowly oblong-lanceolate to oblong or narrowly ovate, mucronately acute, rounded or narrowly cuneate at base, entire or exceptionally with 1 to 3 asymmetrical teeth, scarcely revolute, 2.5 to 5 cm. long, 1 to 2 cm. broad (usually the smaller dimensions), glabrous and glossy above, very minutely and appressed stellate-canescent beneath; veins about 10 pairs, looping, very fine and indistinct; petioles tomentulose, 3 mm. long. Fruit annual, scattered on a puberulent peduncle 2 x 40 to 60 mm.; cups turbinate with an elongated scaly stipe, about 10 mm. in diameter, with thin appressed acute very canescent more or less serially arranged scales; acorns fusiform, glossy brown with paler striae, 20 to 25 mm. long, covered at the base only. (See Fig. 10).

The type of *Q. fusiformis* was collected at Kerrville, Texas, and the species ranges southwesterly from there to northwestern Coahuila, southern Coahuila, and along the eastern base of the Sierra Madre Oriental to central Nuevo Leon, occurring in Texas as far west as the Devils River. Although this species grows as a shrub or small tree in the type locality, in Mexico it forms a large spreading tree with much the same habit as *Q. virginiana* Mill., to which it is most closely related. These two species overlap in range on the Edwards Pleateu of Texas, and perhaps in that area they are not distinct. However, the vast bulk of material of *Q. fusiformis* occurs in Mexico and adjacent Texas counties where the characters of the type population are much accentuated. The markedly fusiform fruit and toothed leaves (at least a few on each branch) rather definitely distinguish our species from *Q. virginiana*. These characters suggest the somewhat more distantly related *Q. brandegei* Goldm. of Baja California.

ERYTHROBALANUS. Black Oaks

11. *Quercus Emoryi* Torrey in Emory, Notes Mil. Record 151. 1848

*Q. hastata* Liebmann, Overs. Dansk. Vidensk. Selsk. Forhandl. **1854**:171. 1854.

Twigs about 2 mm. in diameter, scarcely fluted, from yellowish-scurfy-tomentose glabrescent and rather glossy red with scarcely discernible lenticels. Buds brown, glabrate and rather glossy, ovoid, 2 x 3 or sometimes 3 x 8 mm. Leaves deciduous, thick and hard, elliptic, oblong, ovate, or sagittate, mucronately acute, truncate at base or cordate, entire or unequally or repandly toothed, flat, 3 to sometimes 6 cm. long, 1 to 2 cm. broad, glossy, glabrous above or somewhat puberulent along the midrib, glabrous below except for a tuft of stellate hairs on each side of the base of the midrib; veins about 10 pairs, looped, slightly raised on both surfaces; petioles somewhat tomentose, 1 x 5 mm. Staminate catkins about 40 mm. long, fleecy, the glabrous rounded anthers little exserted. Fruit annual, solitary or paired on peduncles 3 mm. long or less; cups hemispheric, about 10 mm. in diameter, with thin appressed blunt canes-

Fig. 11. *Quercus Emoryi* Torr. Fig. 12. *Quercus Tharpii* C. H. Mull.

cent scales; acorns narrowly ellipsoid, 15 to 20 or rarely only 10 mm. long, 8 or sometimes 5 mm. in diameter, silkily buff-scurfy, about one-third included. (See Fig. 11).

*Q. Emoryi* was first described from western Texas where it occurs in the Chisos, Davis, Guadalupe, and several minor mountain ranges. It ranges to northern Coahuila, Chihuahua Sonora, Arizona, and New Mexico. The species shares the habitat of *Q. grisea* in pinyon and juniper zones where it occurs usually as a shrub or small tree. In moist protected sites such as arroyo and canyon floors, *Q. Emoryi* forms large trees up to two feet in diameter and fifty feet in height. The nuts of this species, unlike those of most species of black oaks, are nearly free of tannin and hence quite palatable. They were much used by the Indians as an article of food.

*Q. Emoryi* is not closely related to any other United States species but rather has its affinities in *Q. durifolia* von Seemen and *Q. duraznillo* Trel. of the Sierra Madre Occidental of Durango and Chihuahua. It is very doubtful that *Q. duraznillo* can be held distinct from *Q. Emoryi.*

12. *Quercus Tharpii* C. H. Muller, Amer. Midl. Nat. 19:586. 1938

Twigs 2 mm. in diameter, hardly fluted, dull reddish-brown becoming quite gray with scarcely discernible lenticels, from sparsely stellate quickly glabrescent. Buds scarcely 1 x 2 mm., acute, glabrous, stipules deciduous. Leaves deciduous? (the type apparently evergreen but probably due to renewed growth in late summer), 5 to 9 cm. long, 1.5 to 2.5 cm. broad, characteristically oblanceolate, the short apices acute, bases cuneate or somewhat rounded, rather deeply 4- or 5-aristate-dentate on each side or entire below the middle, from remotely stellate-puberulent quickly glabrate and shiny on both surfaces, hard coriaceous; veins about 5 pairs, passing into the teeth and with anastomosing intermediates, somewhat prominent on both surface; petioles 5 to 7 mm. long, glabrate like the blades, flatened above. Flowers and fruit unknown. (See Fig. 12).

*Q. Tharpii* is known definitely only from the Chisos Mountains of Texas. but herbarium specimens have been seen from the Davis Mountains which probably belong to this species. The Davis Mountains material unfortunately seems to have been lost. *Q. Tharpii* is a small tree occurring rarely at about 6,500 feet altitude in moist, wooded canyons. It is not closely related to any other Texas species, though its affinity for *Q. Emoryi* is evident. It rather is closest to *Q. duraznillo* f. *pinetorum* Trel. Apparently *Q. duraznillo* is only an entire-leafed form of *Q. Emoryi,* and the form *pinetorum* seems to represent a totally different species which further study might prove distinct. *Q. Tharpii* represents a much wider variation from the *Q. Emoryi* parent stock. It may be distinguished from *Q. Emoryi* by its leaves which are characteristically widest above the middle, much narrowed below, manifestly toothed or lobed, and lacking the tufts of stellate hairs on each side of the base of the midrib beneath characteristic of *Q. Emoryi.*

13. *Quercus hypoleucoides* A. Camus, Bull. Mus. Nat. d'Hist. Nat. 2. sér. 4:124. 1932

*Q. hypoleuca* Engelmann, Trans. St. Louis Acad. **3**:384. 1876. Not *Q. hypoleuca* Miquel, Fl. Ind. Bot. **1**:869. 1855. Not *Q. hypoleuca* Gandoger, Fl. Eur. **21**:37. 1890.

*Q. confertifolia* Torrey, U. S. and Mex. Bound. Surv. Rpt. 207. 1840. Not *Q. confertifolia* Humboldt and Bonpland, Pl. Aequinoct. **2**:53. *pl. 94.* 1809.

Twigs 2 to 3 mm. in diameter, little fluted, rather persistently gray-short-tomentose, red with scarcely evident lenticels or somewhat pruinose in age. Buds reddish-brown, glabrescent with ciliate scales, ovoid, scarcely 2 x 3 mm. Leaves more or less evergreen, lanceolate, aristately very acute, rounded at the bases, typically entire, or with a few small setifrous teeth or deeply and coarsely serrate above, revolute, 5 to 8 or 10 cm. long, 1.5 to 3 cm. broad, glabrous and glaucous- or bluish-green above, densely canescent-tomentulose beneath; veins about 10 or 12 pairs, or with evanescent intermediates, branched and obscurely looping near the margin, somewhat impressed above, the reticulum inconspicuous; petioles tomentulose or glabrescent, 1.5 x 15 mm. Staminate catkins 60 mm. long, white-pilose, rather loosely flowered, the glabrous ellipsoid anthers exserted. Pistillate catkins 5 to 10 mm. long, 1- or 2-flowered at the end. Fruit annual, solitary or unequally paired on more or less hoary peduncles 2 x 5 to 15 mm.; cups turbinately hemispheric, 10 mm. in diameter, with thin appressed blunt scales very tomentulose but readily abraded and then pale brown; acorns narrowly oblong, about one-third included. (Fee Fig. 13).

*Q. hypoleucoides* was first collected in New Mexico. It ranges through western Texas (Davis Mountains and Guadalupe Mountains) to northern Coahuila, Chihuahua, Sonora, and Arizona. It forms a moderate or small tree to forty feet in height, or it may occur as a shrub only six feet tall. The species is abundant between 7,000 and 9,000 feet of altitude, but it reaches its best development on protected canyon sites or on moist north slopes.

*Q. hypoleucoides* is most closely related to *Q. scytophylla* Liebm. and *Q. epileuca* Trel. of southwestern and northwestern Mexico. (See the discussion of the relationships of *Q. livermorensis* below.) From the Mexican species *Q. hypoleucoides* is readily distinguished by its very narrow leaves.

It is unfortunate that Engelmann's widely known name *hypoleuca* proved unavailable for this species, and Mme. Camus' effort to retain the original root of Engelmann's name by applying the epithet *hypoleucoides* is therefore commendable. However, it is equally unfortunate that she chose the suffix *-oides*, for to one unfamiliar with the synonymy of this species her name would suggest that there exists another species in the Southwest which resembles Engelmann's *Q. hypoleuca*, which is not meant.

14. *Quercus livermorensis* C. H. Muller, Amer. Midl. Nat. 19:586. 1938

Twigs 2 to 2.5 mm. in diameter, very inconspicuously fluted, reddish-brown, rather persistently short-hairy the second year with inconspicuous lenticels. Buds 3 to 4 mm. long, acute, hairy, the stipules deciduous. Leaves evergreen, oblong

to oblanceolate, acute, deeply artistately 3- to 4-toothed on each side except about the cuneate or inequilaterally rounded base, margins revolute, blades 9 to 13 cm. long, 3 to 4.5 cm. broad, from sparsely low-stellate-hairy glabrate and shiny above and persistently short-velvety beneath with conspicuous domatia; veins about 4 or 5 pairs passing into the teeth where those are present and having anastomosing intermediates, slightly impressed above and quite prominent beneath; petioles 15 to 20 mm. long, low-stellate-hairy or glabrate. Staminate catkins about 25 mm. long, the peduncle hairy, loosely flowered, anthers exserted. Pistillate catkins 1- to 3-flowered on a very short, hairy peduncle. Fruit biennial, solitary or paired, subsessile. Mature fruit unknown. (See Fig. 14).

*Q. livermorensis* is known only from Mt. Livermore in the Davis Mountains of western Texas. It is very closely related to *Q. hypoleucoides* A. Camus although superficially it is very unlike that species. These two species may be distinguished by the larger, more coarsely dentate,and strikingly less tomentose leaves with fewer principal veins and larger petioles of *Q. livermorensis*. The relationship of this species to *Q. hypoleucoides* is similar in many respects to the affinities of *Q. scytophylla* Liebm. and *Q. epileuca* Trel. of western Mexico to *Q. hypoleucoides*. Perhaps *Q. livermorensis* on the one hand and the *Scytophyllae* on the other represent simultaneous divergence from the parental stock of *Q. hypoleucoides*.

15. *Quercus graciliformis* C. H. Muller, Torreya 34:120. 1934

Twigs 1.5 mm. in diameter or less, fluted, quickly glabrate, deep glossy red to brown, gray the second year with a few scarcely evident small buff lenticels. Buds 1 to 1.5 x 1.5 to 2 mm., ovoid, glossy brown, the scales ciliate. Leaves deciduous, narrowly lanceolate, long attenuate, cuneate at the base, setaceously and often unequally 8- to 10-toothed with somewhat deep rounded sinuses (rarely very shallow), 8 to 10 cm. long, 2 to 3 cm. broad, soon glabrate, entirely smooth or very rarely an axillary tuft beneath, glossy green above, more dull and slightly coppery beneath; veins about 10 pairs, much branched but rarely looped, usually passing alternately into the teeth, scarcely raised above but more prominent beneath; petioles glabrous, deep red at the base shading into straw color, dorsally flattened, very slender (0.5 x 15 to 20 mm.), very flexible. Pistillate catkins about 4 mm. long, about 2-flowered, deep reddish-brown. Fruit biennial, solitary or sometimes paired, subsessile; cups scarcely 10 mm. in diameter, deep-saucer-shaped, about 3 mm. deep, with thin appressed light brown scales with narrowly rounded ciliate apices and canescent along the middorsal area; acorns acutely ovoid, about 18 mm. long and 10 mm. broad, densely fine-pubescent, with longitudinal dark striae, enclosed only at the base. (See Fig. 15).

*Q. graciliformis* is known only from Blue Creek Canyon in the Chisos Mountains of western Texas where it forms groves of small trees along the arroyo bank at an altitude of about 5,500 feet. The species is very closely related to *Q. Canbyi* Trel. in the Sierra Madre Oriental of Nuevo Leon and

Fig. 13. *Quercus hypoleucoides* A. Camus. Fig. 14. *Quercus livermorensis* C. H. Mull.

has no affinities for any other Texas species. From *Q. Canbyi* it is distinguished by its acute acorns enclosed only at the bases by very shallow cups and by its more slender twigs and more attenuately lobed leaves.

15a. **Quercus graciliformis f. parvilobata** comb. nov.

*Q. graciliformis* var. *parvilobata* C. H. Muller, Torreya **34**:122. 1934. (Without Latin diagnosis.)

A forma typica foliis 5 cm. longis integris vel pauce parvilobatis basi rotundatis pubescentibus, petiolis 10 mm. longis recedit.

Leaves 5 cm. long, 1.5 cm. broad, with a few short teeth or entire, bases rounded, persistently somewhat scurfy-pubescent; petioles about 10 mm. long.

This can scarcely be regarded as a variety since it occurs with the species and appears to be only a rather extreme form of that plant. It is known only in the Chisos Mountains of western Texas.

16. *Quercus Gravesii* Sudworth, U. S. Dept. Agr. Misc. Circ. 92:86. 1927

*Q. coccinea* var. *microcarpa* Torrey, U. S. and Mex. Bound. Surv. Rpt. **2**:206. 1859.
*Q. texana* var. *chesosensis* Sargent, Bot. Gaz. **65**:423. 1918.
*Q. texana* var. *stellapila* Sargent, loc. cit.
*Q. stellipila* Parks in Cory, Rhodora **38**:405. 1936.
*Q. chesosensis* C. H. Muller, Amer. Midl. Nat. **18**:850. 1937.

Twigs slender (1 to 2 mm.), fluted, glabrous or from fulvous stellate-scurfy glabrate and reddish-brown with few rather inconspicuous lenticels. Buds about 3 to 4 x 2 to 2.5 mm., acute, the scales dull and reddish-brown, ciliate, and somewhat scurfy; stipules early caducous. Leaves 5 to 10 or 14 cm. long, 4 to 8 or 12 cm. broad, ovate to broadly lanceolate or obovate in outline, acute or obtuse, basally rounded to occasionally cuneate, typically 2- or 3-lobed on each side with deep rounded sinuses, the lobes typically cuneate and entire or oblong and setaceously toothed, the terminal lobe much elongated, entire, toothed, or slightly lobed, atypical leaves sometimes merely low-toothed, or the lobes occasionally clavately divided, upper surface dark green, dully shining, glabrous, the veins and reticulum distinctly raised, lower surface cuprous-green, more dull, glabrous, glabrate, or rather persistently but sparsely minute-stellate-scurfy, with or without dense tufts in the axils of the principal veins, veins and reticulum raised; veins as many as the lobes and passing into the teeth, with secondary intermediates slightly raised above; petioles 8 to usually 15 or 25 mm. long, 1 mm. or less thick, glabrous or glabrate. Fruit biennial, solitary or paired on a peduncle up to 4 mm. long or subsessile; cups deeply turbinate, about 10 or 12 mm. in diameter and 5 or 8 mm. deep (or 10 mm. by the elongation of the base), the scales closely appressed, narrowly rounded, light brown, scurfy with glabrous and sometimes dark brown margins; acorns oval, about 12 to 15 mm. long and 8 to 10 mm. thick, minutely silky all over, light brown. (See Fig. 16).

The type of *Q. Gravesii* (as *Q. texana* var. *chesosensis*) was collected in the Chisos Mountains of western Texas. The species occurs also in the Davis

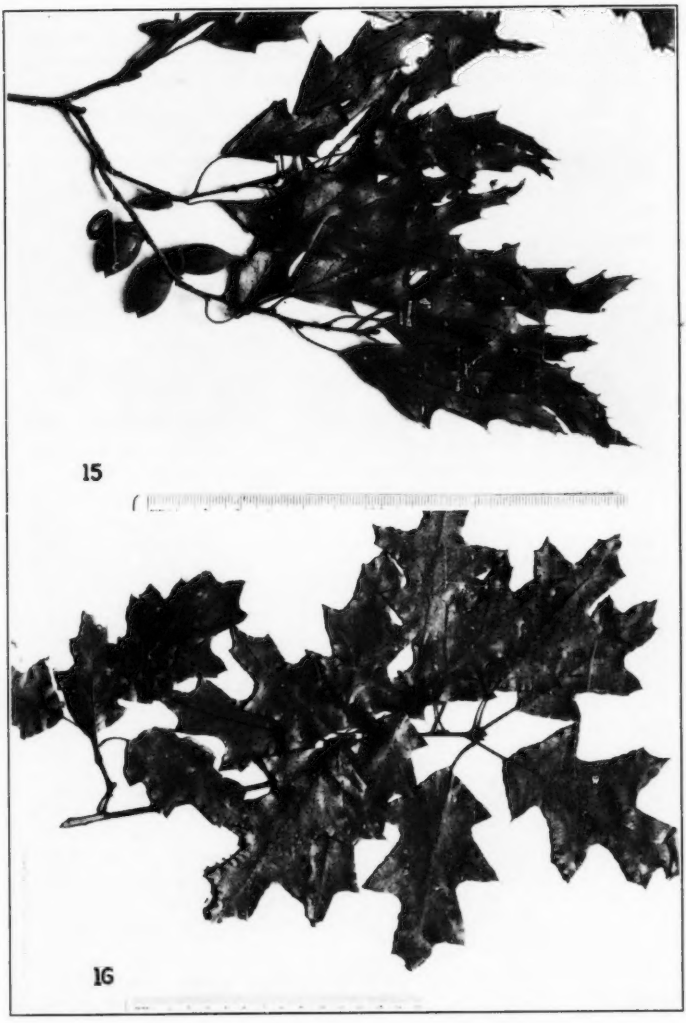


Fig. 15. *Quercus graciliformis* C. H. Mull. Fig. 16. *Quercus Gravesii* Sudw.

Mountains and becomes very abundant in the mountains of Coahuila. It is most closely related to *Q. texana* Buckl. of the Edwards Plateau and might readily be confused with that species where their ranges approach one another near the Pecos River. The small acorns, deep cups, and usually elongate terminal leaf lobes of *Q. Gravesii* should distinguish it clearly from *Q. texana*.

The form known as *Q. stellipila* can not be given even varietal or formal rank. Its only variation from the type is the persistence of its scant pubescence, a character which occurs inconsequentially scattered throughout the range of the species.

Both *Q. Gravesii* and *Q. texana* belong to the series *Coccineae* which is characterized by species whose leaves turn scarlet in autumn. *Q. Gravesii* is the only species in western Texas (and, for that matter, in the whole of the western United States and Mexico) which exhibits scarlet autumnal coloration. The slopes of the Chisos Mountains at the proper season are usually a solid mass of color as a result of this species.

17. *Quercus robusta* C. H. Muller, Torreya 34:119. 1934

Twigs about 2 or 3 mm. in diameter, obscurely fluted, densely short-stellate-hairy the first year or late-glabrate, dark red-brown becoming gray in the second year with numerous small lenticels (evident when not obscured by pubescence). Buds 1.5 x 3 to 4 mm., oblong to acutely ovoid, glossy brown, the scales ciliate. Leaves deciduous, 6 to 11 cm. long, 2.5 to 5 cm. broad, stiff, coriaceous, dull green, not turning crimson in autumn, broadly lanceolate to acutely ovate, often long attenuate (by the elongation of the terminal lobe), rounded at the base, frequently broadly cuneate, truncate, or even shallowly cordate, setaceously and unequally 8-lobed, with deep rounded sinuses, the terminal pair often reduced to mere teeth on the terminal lobe, short fascicled hairs persistent especially above and along the midrib beneath, frequently one or two denser axillary tufts beneath; veins about 8 pairs, branching but hardly looped, scarcely raised above but prominent beneath, usually alternately passing into the lobes; petioles 0.5 to 1 x 10 to 20 mm., stiff, stellate-hairy or finally glabrate, dark red at the base shading into straw color above, dorsally flattened. Fruit biennial, solitary or, if paired, one usually not developing fully, the mature fruit borne on a short peduncle (2.5 x 5 or 6 mm.) or subsessile; cups about 12 mm. in diameter and 8 mm. in depth with thin appressed somewhat elongated and apically narrowly rounded light brown ciliate scales densely pubescent dorsally with easily removed silvery white hairs; acorns oblong, almost cylindrical, broadly rounded at the apex, about 17 to 22 mm. long and 8 to 10 mm. in diameter, finely dense-pubescent, with longitudinal dark striae, one-third or more included. (See Fig. 17).

*Q. robusta* is known only from Oak Canyon at the foot of the Chisos Mountains in western Texas where it occurs as a large tree with broadly spreading branches resembling the habit of *Q. virginiana* Mill. of the East and of *Q. agrifolia* Née of the California coast. *Q. robusta* together with *Q. tardifolia* represents a natural series not closely related to any other species. The series

Fig. 17. *Quercus robusta* C. H. Mull. Fig. 18. *Quercus tardifolia* C. H. Mull.

shows affinities to the *Coccineae* to which *Q. Gravesii* belongs, but it is clearly distinguished from the *Coccineae* by its leaf pubescence, the failure of its leaves to become crimson in autumn, and the heaviness and stiffness of its branchlets.

18. *Quercus tardifolia* C. H. Muller, Bull. Torr. Bot. Club 63:154. 1936

Twigs 2 mm. in diameter, somewhat fluted, at first densely stellate-tomentose, glabrous or nearly so the second year and red-brown with minute inconspicuous lenticels, becoming finally gray with the lenticels larger but inconspicuously colored. Buds acutely fusiform, 2 x 3.5 to 4 mm., hairy at the tip, the broadly truncate scales usually split at the end, slightly hoary and often ciliate. Leaves evergreen, the young ones appearing in dense tomentum in midsummer, 5 to 9 cm. long, 2.5 to 5.5 cm. broad, oblong-ovate to subobovate, 6- to 8-lobed by shallow or moderate sinuses, the lobes aristately tipped, entire or rarely 2-toothed, short and sub-right-angular like the apex, subequilaterally moderately cordate at the base, stiff coriaceous in texture, the upper surface dull blue-green, glabrate, the lower surface detachably loosely stellate-tomentose; veins about 8 pairs, alternately passing into the teeth, hardly evident above but prominent beneath; petioles rather stiff, 1 to 1.5 x 15 to 20 mm., red at the bases, glabrate with the leaves. Fruit biennial; young cups with thin appressed short-truncate hoary or glabrate scales. Mature fruit unknown. (See Fig. 18).

*Q. tardifolia* is known only from one canyon at 7,000 feet altitude in the Chisos Mountains of western Texas where it occurs sparsely as a low tree with stiff branches, growing in clumps with much the same habit as young trees of *Q. marilandica* Muench. farther east. *Q. tardifolia* is rather closely related to *Q. robusta* from which it is quite readily distinguished by its evergreen and shrubby habit, and its loosely tomentose leaves as opposed to the broadly spreading large tree habit, deciduous leaves, and close pubescence of *Q. robusta*.

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# A Revision of Choisya

Cornelius H. Muller

*Choisya ternata* has been widely cultivated in the warmer parts of Europe and America. Since it is a very striking ornamental, it is exceedingly popular. Certain of the other species should make attractive dwarf shrubs, notably *C. dumosa* and *C. Katherinae*. These latter species, however, are all exceedingly narrow-leaved and bear their flowers on single pedicels clustered near the tips of the branches rather than in diffuse panicles.

The genus *Choisya* was based on *Choisya ternata* by Humboldt, Bonpland, and Kunth[1] in 1823. It is a member of the family *Rutaceae*, subfamily *Rutoidupeae*, tribe *Xanthoxyleae*, subtribe *Choisyinae*.[2] In 1824 de Candolle[3] treated *Choisya* and cited as a synonym the name *Plenckia* Moc. & Sessé from the inedited manuscript of the latter authors (not *Plenckia* Raf.). In 1825 Llave[4] proposed the generic name *Juliana* for the same plant. Regel[5] in 1876 described *C. grandiflora* which has proven to be synonymous with *C. ternata*.

Torrey[6] in 1854 described the genus *Astrophyllum* based upon *A. dumosupum*. Gray[7] regarded this plant as congeneric with *Choisya* in 1888. Wilson[8] and Standley[9] followed Gray in reducing *Astrophyllum* to synonymy under *Choisya*. Standley (l.c.) added *C. arizonica*, *C. Palmeri*, and *C. mollis* (all of *Astrophyllum* affinities) as new species in his revision of the genus. Unfortunately his key employs as one of its principal criteria the nature of the pubescence of the pedicels, that is, whether the pubescence is appressed or spreading. *C. dumosa*, which is credited with appressed pubescence, has both kinds indiscriminately mixed or singly, and the character is scarcely more definite in several of the other species.

*Choisya* and Torrey's *Astrophyllum* have consistently been regarded as congeneric since Gray's reduction of the latter name. Standley suggested that they might prove distinct if the fruits of *C. ternata* were known. Jussieu and Baillon had given partial descriptions of the fruits as mentioned by Gray (l.c). Good fruiting material of the closely related *C. neglecta* is now available, and there appear to be no differences upon which *Astrophyllum* can rest. Nor are

1 Humboldt, Bonpland, & Kunth, Nov. Gen. et Sp. **6**:4. *t. 513*. 1823.

2 Engler in Engler & Prantl, Nat. Pflanzenfam. 2nd ed. **19**[a]:205-240. 1931.

3 De Candolle, Prodr. **1**:724. 1824.

4 Llave in Llave & Lex., Nov. Veg. Descr. fasc. **2**:10. 1825.

5 Regel, Gartenfl. **1876**:257. 1876; Act. Hort. Petrop. **4**:336. 1876.

6 Torrey, U. S. Expl. Miss. Pacif. **2**(4):161. 1854; U. S. & Mex. Bound. Surv. Rpt. **2**:42. 1859.

7 Gray, Proc. Amer. Acad. **23**:224. 1888.

8 Wilson, N. Amer. Flora **25**(3):205. 1911.

9 Standley, Proc. Biol. Soc. Wash. **27**:221-224. 1914.

the "slight differences in the flowers," mentioned by Standley, of any greater magnitude than those between the various species within the respective subgenera. Yet, the *Astrophyllum* group differs so markedly in general appearance from *Euchoisya (C. ternata* and *C. neglecta)* that one is much tempted to recognize Torrey's genus. Lacking any flower or fruit characters, however, it seems best to treat the two entities as subgenera. The trifoliolate leaves of *Euchoisya* rather definitely suggest a pinnate condition, the terminal leaflet usually being markedly petiolulate. However, there is no suggestion of a rachis, and the petiolules are always basally articulated. The occasional trifoliolate leaves of *Astrophyllum* are always definitely palmate, there being no indication of a petiolule. The broad, nearly flat leaflets of *Euchoisya* are strikingly opposed to the linear, usually strongly revolute leaflets of *Astrophyllum. Astrophyllum* usually bears its flowers singly in the axils of the leaves, while in *Euchoisya* a definite and often profuse panicle is produced, except that in *C. neglecta* this is usually reduced to a solitary flower on a definite bracteate pedicel and peduncle. This latter distinction is not always constant.

In the citations of specimens the parenthetic symbols refer to the herbaria in which the specimens are deposited, as follows: NA=National Arboretum, Washington, D. C.; US=U. S. National Herbarium, Washington, D. C.; NY=New York Botanical Garden, New York; G=Gray Herbarium, Harvard University, Cambridge, Mass.; AA=Arnold Arboretum, Harvard University, Jamaica Plain, Mass.; F=Field Museum, Chicago; M=Missouri Botanical Garden, St. Louis; UC=University of California, Berkeley; S=Dudley Herbarium, Stanford University, Calif. The author is indebted to the curators of these herbaria for permission to study their collections.

## Choisya H.B.K.

*Choisya* H. B. K., Nov. Gen. et Sp. **6**:4. *t. 513.* 1823.

*Astrophyllum* Torr., U. S. Expl. Miss. Pacif. **2**(4):161. 1854; U. S. & Mex. Bound. Surv. Rpt. **2**:42. 1859.

*Plenckia* Moc. & Sessé ex DC. Prodr. **1**:724. 1824. As synonym. Not *Plenckia* Raf.

*Juliana* Llave in Llave & Lex., Nov. Veg. Descr. fasc. **2**:10. 1825.

Aromatic shrubs, often prominently glandular; leaves opposite or subopposite, palmately 3- to 12-foliolate or apparently pinnately 3-foliolate; flowers terminally or laterally paniculate or solitary in the axils of the leaves; panicle branches and pedicels bracteate; sepals 4 or usually 5, deciduous; petals 4 or usually 5, large (1 to 2 cm. long), white, glabrous; stamens 8 or usually 10, in two series, the inner (opposite the petals) much shorter than the outer (opposite the sepals), the filaments broadly subulate with attenuate apices, rather fleshy, the 2-celled anthers oval to nearly oblong or sagittate by the divergence of the cells below the bases of the short connectives, attached basally; ovaries hirsute, of 5 basally adherent carpels each with a glabrous apical horn connivent about the centrally attached style; style 5-sulcate, the sulcae straight or twisted, the elements readily detachable from one another and adhering to the maturing carpels; stigmas capitate, 5-lobed; fruit of 2 or rarely 1 or 3 or more matured carpels, the horns migrating to a dorsal position, the persistent style bases

apical; carpels dehiscent down the ventral suture and dorsally as far as the dorsal horn, the endocarp horny and readily separable from the exocarp, sometimes deciduous with the seeds; seeds one or two in each carpel, reniform if solitary, roughly orbicular if two, the coats shiny dark brown and longitudinally striate-reticulate, the concave ventral side with a deep pit-like hilum.

*Type—Choisya ternata* H.B.K.

### Key to the Subgenera and Species

A. Leaves always subpinnately trifoliolate, the leaflets broad (5 to usually 10, 20, or 30 mm.), broadly oblanceolate to obovate; inflorescence paniculate or reduced to one or a few flowers on a peduncle and pedicel.....Subgen. *Euchoisya*.

B. Leaflets 40 to 70 or rarely 30 mm. long, 15 to 35 or rarely 10 mm. wide, acute or rounded but very rarely emarginate; petioles of mature leaves usually 30 to 50 mm. long; inflorescence a panicle of several flowers, the whole 3.5 to 10 cm. long.....1. *C. ternata*.

BB. Leaflets 10 to 20 or rarely 30 to 40 mm. long, 5 to 8 or rarely 12 mm. wide, broadly rounded and definitely but obscurely emarginate; petioles of mature leaves 4 to 10 or 15 mm. long; flowers solitary or rarely two or three in a reduced panicle not over 1.5 cm. long .....2. *C. neglecta*.

AA. Leaves 3- to 12-foliolate, always strictly palmate, leaflets 1 to 4 mm. broad, linear, several to many times longer than broad; flowers solitary in the axils of the leaves or rarely 2 pedicels on a much reduced peduncle.....Subgen. *Astrophyllum*.

C. Glands on leaflets and petioles quite prominent, protruding from 0.25 to usually 0.5 mm., the parts therefore obviously denticulate; leaves usually glabrate or sparingly appressed pubescent.

D. Petioles always more than half as long as the leaflets and frequently equalling them, leaflets 10 to 35 mm. long, usually 8 to 12 in number .....3. *C. dumosa*.

DD. Petioles one-third as long as the leaflets or much shorter, leaflets 25 to 50 mm. long, usually 3 to 5 in number.....4. *C. arizonica*.

CC. Glands on leaflets and petioles not markedly prominent, protruding less than 0.2 mm., leaflets if denticulate, repandly so and not by mere protrusion of glands, leaves variously copiously pubescent.

E. Leaves copiously pubescent on both surfaces with curved or appressed short hairs, leaflets attenuately narrowed basally, 7 to 10 in number .....5. *C. Katherinae*.

EE. Leaves straight-spreading-pubescent at least on the upper surface, leaflets moderately and somewhat abruptly if at all narrowed basally.

F. Leaflets uniformly 1 to 1.25 mm. broad, entire, strongly revolute, copiously pubescent with minute short spreading hairs scarcely more than 0.1 mm. long.....6. *C. Palmeri*.

FF. Leaflets conspicuously narrowed at both ends, 2 to 4 mm. wide, repandly denticulate, flat, copiously pilose with fine spreading hairs 0.5 mm. long.....7. *C. mollis*.

### Subgen. **Euchoisya** subgen. nov.

*Plenckia* Moc. & Sessé (l. c.). As genus.
*Juliana* Llave (l.c.). As genus.

Folia subpinnato-trifoliolata, foliola 5-20 mm. lata obovata vel lato oblanceolata plana vel minute revoluta, inflorescentia paniculata vel rare simplex.

Leaves subpinnately 3-foliolate, the terminal leaflet definitely petiolulate, the petioulule basally articulated; leaflets 5 to usually 20 or 30 mm. broad, broadly oblanceolate to obovate, flat with markedly cartilaginous margins or minutely revolute, glands not prominent; inflorescence terminal or lateral, paniculate or rarely reduced to a solitary flower on a short peduncle and pedicel.

*Type—Choisya ternata* H.B.K.

1. *Choisya ternata* H.B.K., Nov. Gen. et Sp. 6:6. *t. 513.* 1823

*Juliana caryophillata* Llave in Llave & Lex., Nov. Veg. Descr. fasc. **2**:10. 1825.
*C. grandiflora* Regel, Gartenfl. **1876**:257. 1876; Act. Hort. Petrop. **4**:336. 1876.

Twigs apparently glandless, minutely short-spreading-pubescent and persistently scurfy for several years. Leaves trifoliolate, digitate but the terminal leaflet petiolulate and therefore apparently subpinnate, leaflets narrowly elliptic to oblanceolate, the apices rounded or very rarely minutely emarginate, the bases rather attenuately narrowed, widest above the middle, about 4 or 5 cm. long at maturity and 1 to 3 cm. broad, margins minutely cartilaginous, glabrous save for the margins and the midrib on both surfaces sparsely hirtellous, both surfaces inconspicuously glandular-punctate, veins 7 to 11 on each side; petioles 2 to 4 cm. long, deeply channeled above, pubescent especially above and toward the apex. Inflorescence of one or several lateral panicles grouped near the ends of the branches, each panicle 3 to 5 or even 10 cm. long; peduncles 3- to 6-flowered or rarely with only 2 flowers; pedicels opposite or alternate, 1.5 to 4 cm. long, basally bracted with one deciduous acute bract 5 to 7 mm. long and again medially with a pair of subopposite scales 1 to 2.5 mm. long, the whole inflorescence spreading-pubescent. Sepals quickly deciduous, about 3 to 4 mm. long, ovate, thin, the margins ciliate, inconspicuously punctate-glandular on the back. Petals 10 to 15 or rarely 20 mm. long and about 4.5 to 6 mm. broad, oblanceolate, inconspicuously glandular. Stamens markedly different, filaments of the inner series (opposite the petals) about 3 to 4 or rarely only 2.5 mm. long, the outer series 4 to 5.5 or rarely only 3 mm. long and about half again as thick as the inner series; anthers oval, about 0.75 to 1 mm. long, those of the inner series often the smaller. Ovary prominently lobed and about 2.5 to 3 mm. long and 2 mm. broad at anthesis, the lobes not distinctly gland-tipped at the glabrous apices, densely pubescent; style about 1.5 to 2 mm. long, the partially fused elements twisted and the style crooked, scantily pubescent. Fruit similar to that of the following species (ex. char. fide Gray).

*Type locality*—"Colitur in et prope Mexico, alt. 1,168 hex."

MEXICO—MEXICO: "in montibus supra Tolucam," April 1834, *G. Andrieux* 477 (G).—SAN LUIS POTOSI: "chiefly in the region of San Luis Potosí," 1878, *C. C. Parry* and *Edw. Palmer* 229 (G).—PUEBLA: Esperanza, "Jardin," Nov. 16-19, 1907, *C. Arséne* without number (US). "Ex Hort. Bot. Mex.," Oct. 1829, *Scheide* without number (US). [Apparently cultivated]: 1838, *Fischer* without number (NY); March 1848, *Halstead* without number (NY); Dec. 19, 1869, *Belemek* without number (NY).

UNITED STATES—CALIFORNIA: Santa Barbara, Nov. 2, 1908, *I. J. Condit* without number (S); Santa Barbara, Franceschi Nursery, May 4, 1911, *F. W. Wight* 4884 (NA); Santa Barbara, May 1907, *H. M. Hall* without number (UC); Altadena,

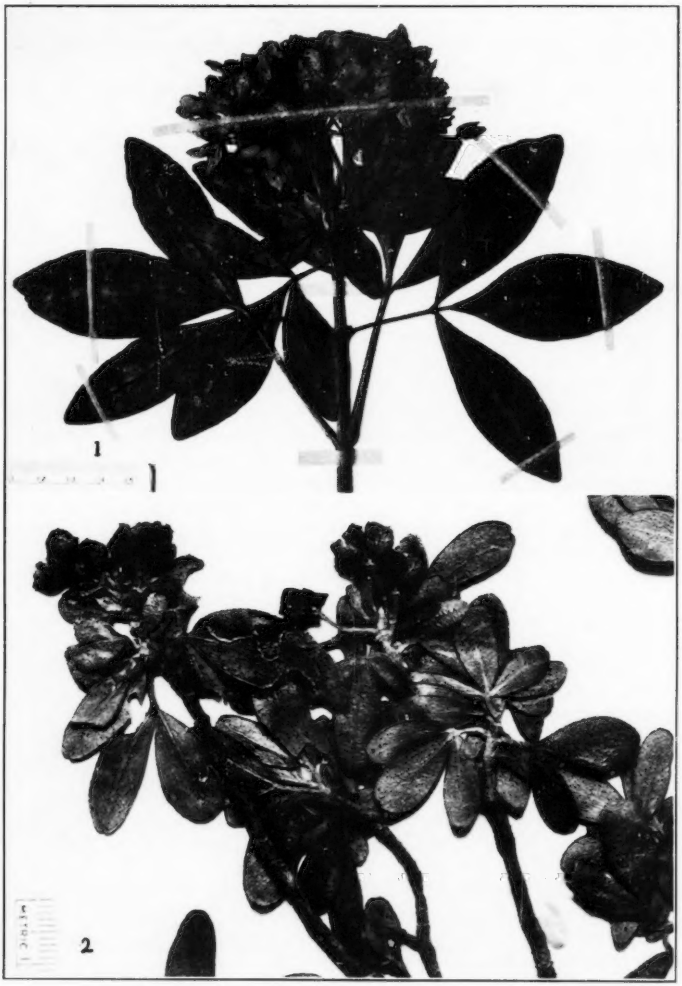


Fig. 1. *Choisya ternata* H. B. K. Fig. 2. *Choisya neglecta* C. H. Mull.

May 2, 1911, *W. F. Wight* 4849 (NA); San Francisco, Nov. 15, 1930, *L. S. Rose* without number (NA); San Francisco, Golden Gate Park, March 11, 1915, *A. Eastwood* without number (AA); June 4, 1915, *A. Eastwood* without number (US,AA); Golden Gate Park, July 31, 1907, *W. F. Wight* 1748 (NA); Berkeley, May 1911, *C. J. Wight* without number (NA); Botanical Garden, Univ. of Calif., Berkeley, Jan. 2, 1914, *H. A. Walker* 3307 (NA); Del Monte, April 24, 1918, *J. F. Collins* without number (G); Univ. of Calif. Campus, Berkeley, March 10, 1931, *E. B. Copeland* without number (UC).—OREGON: Salem, May 1922, *J. C. Nelson* without number (G).

GREAT BRITAIN—Kew Gardens, May 2, 1906, *C. Schneider* without number (AA); Kew, May 20, 1901, *A. Rehder* without number (AA); Kew, May 3, 1880, *G. Nicholson* 564 (AA); Windsor Park, April 10, 1907, June 7, 1903, Jan. 15, 1904, *R. W. Parker* without number (AA); Royal Horticultural Society Gardens, Wisley, Sept. 1938, *M. A. H. Tincker* without number (M); University Parks, May 1935, *H. L. Dunkley* 258 (NY).

FRANCE—Hort. Vilmorin, Verrieres, *R. L. de Vilmorin* without number or date (AA).

GERMANY—Dahlem, Hort. Bot., May 3, 1923, *R. Schlechter* without number (AA).

AUSTRALIA—NEW SOUTH WALES: Botanical Garden, Sidney, Sept. 1921, *J. N. Zoorman* without number (AA).

*Choisya ternata* is scarcely known outside of cultivation, but the collections from Toluca, Mexico, MEXICO by Andrieux and San Luis Potosi by Parry and Palmer are rather definitely of wild plants. These differ in no appreciable manner from the many cultivated specimens from Mexico and elsewhere. As a matter of fact, the species is a remarkably constant one considering its rather long history of cultivation, for it was widely cultivated about Mexico at the time of its discovery there in the early Nineteenth Century.

### 2. **Choisya neglecta** sp. nov.

Folia trifoliolata, foliola elliptica obovata vel raro lato-oblanceolata cuneata emarginata 15-30 mm. longa 4-10 mm. lata minute revoluta glabrata vel supra hirta subtus glandulosa; petioli 4-10 vel raro 15 mm. longi; flores solitarii axillares; pedunculus obsoletus; pedicelli 6-15 mm. longi 2-bracteati; flores fructusque eis generis similis.

Twigs copiously papillose-glandular, minutely short-appressed-pubescent and persistently scurfy for several years. Leaves trifoliolate, digitate, all leaflets sessile, elliptic to obovate or rarely broadly oblanceolate, basally cuneate and rarely attenuate, apices distinctly emarginate, widest at or above the middle, 15 to 30 mm. long, 4 to 10 mm. broad, margins distinctly revolute, glabrate or sparsely hirtellous especially on the upper surface and along the midrib above, the lower surface including the midrib nearly always glabrous, never ciliate except as the scattered hairs of the upper surface approach the revolute margins, lower surface more saliently glandular than the upper, veins scarcely discernible, 5 or 6 (?) on each side; petioles 4 to 10 or rarely 15 mm. long, inconspicuously if at all channelled above, densely pubescent all over. Flowers solitary in the axils of the leaves near the tips of the branches; pedicels 6 to 15 mm. long, suboppositely 2-bracted much below the middle with quickly caducous chaffy bracts scarcely 3 mm. long, borne on much contracted obsolete peduncles indi-

cately only by the presence of a basal bract 3 to 5 mm. long subtending each pedicel, the whole spreading pubescent. Sepals quickly deciduous, about 3 or 4 mm. long, ovate, thin, the margins ciliate, conspicuously punctate-glandular and sparsely pubescent on the back. Petals 10 to 12 mm. long, about 4 mm. broad, oblanceolate, inconspicuously if at all glandular. Stamens differing widely, the inner series (opposite the petals) 2.5 to 3 mm. long, the outer series (opposite the sepals) about 4 mm. long. Ovary distinctly lobed, prominently gland-tipped at the glabrous apex of each lobe, about 2 mm. long and 1.5 mm. broad at anthesis, densely pubescent; style about 1 to 1.5 mm. long, the elements not twisted and very loosely fused so as to separate quite readily, glabrous or scantily pubescent. Fruit of 2 or 3 carpels, about 4 mm. long, readily splitting apart, sparsely hairy, glandular and purple in color.

MEXICO—PUEBLA: Cerro de Matzize, vicinity of San Luis Tultitlanapa, near Oaxaca, April 1908, *C. A. Purpus* 3396 (US—type as sheet no 841020, NY, G, F, M, UC, S); Cerro de Coatepec, Sierra de Mixteca, July 1907, *C. A. Purpus* 2592, from which the fruit is described, (US, NY, G, AA, M, UC).

Superficially *C. neglecta* appears closely related to *C. ternata*, but the much reduced inflorescence, gland-tipped carpels, straight style elements, nearly glandless petals, small leaves with pubescent upper surfaces, distinctly emarginate apices, strongly revolute margins, and scarcely discernible veins so completely distinguish *C. neglecta* that no doubt can persist concerning its specific rank. The numerous duplicates of Purpus' two Oaxacan collections are very complete and exceedingly constant so that no difficulty was experienced in determining the characters of this species. The difficulty was rather in determining those of the widely cultivated *C. ternata* of which abundant material is available. It was not until the discovery of Parish and Palmer's and Andrieux' two collections of *C. ternata* in the wild that one could be sure that the characters of *C. ternata* were not cultigenic in nature.

Subgen. **Astrophyllum** (Torr.) comb. nov.

*Astrophyllum* Torr., U. S. Expl. Miss. Pacif. **2**(4):161. 1854; U. S. & Mex. Bound. Surv. Rpt. **2**:42. 1859. As genus.

Leaves always palmate, 3- to 12-foliolate, without petiolules, leaflets 1 to 3.5 mm. broad, linear, of uniform width or narrowed at one or both ends, usually markedly revolute, with usually prominent marginal glands; flowers solitary in the axils of the leaves or the pedicels rarely geminate on obsolete penduncles.

*Type—Choisya (Astrophyllum) dumosa* (Torr.) A. Gray.

3. *Choisya dumosa* (Torr.) A. Gray, Proc. Amer. Acad. 23:224. 1888

*Astrophyllum dumosum* Torr., U. S. Expl. Miss. Pacif. **2**(4):161. 1854; U. S. & Mex. Bound. Surv. Rpt. **2**:42. 1859.

Twigs densely or scantily puberulent, never with elongate hairs except rarely about the stem tip, persistently scurfy for several years, prominently warty with raised glands and these often evident for years. Leaves digitate, leaflets 7 or 8 to 12 in number, all sessile and basally articulated, about 15 to 25 or even 35 mm. long, 1.5 to 2 or rarely 2.5 mm. broad, linear, apices rounded and usually

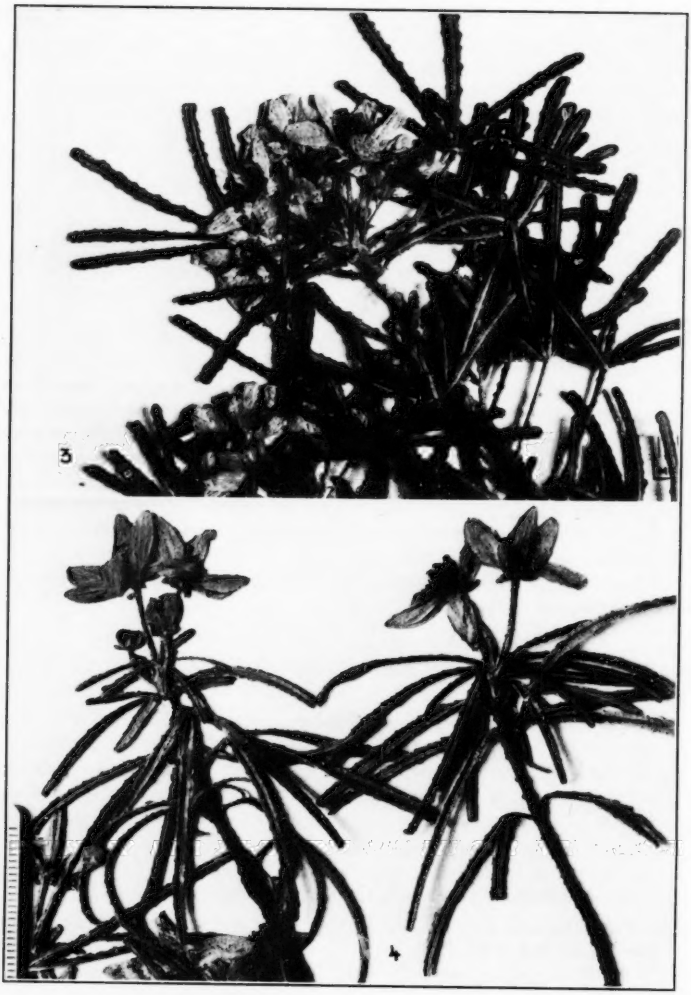


Fig. 3. *Choisya dumosa* (Torr.) A. Gray. Fig. 4. *Choisya arizonica* Standl.

distinctly glandular-emarginate, basally somewhat narrowed, obviously denticulate with glands protruding from 0.25 to usually 0.5 mm., sparsely appressed or spreading hirtellous when young, becoming quite glabrous or sparsely scurfy only along the midrib above toward the base; petioles 12 to 25 or even 30 mm. long, usually quite as long as the leaflets, prominently glandular-warty, glabrate except for the scurfy flattened upper surface. Flowers solitary in the axils of the leaves, crowded toward the tips of the stems, rarely several on a nearly obsolete peduncle not over 5 mm. long, pedicels 10 to 15 or rarely 20 mm. long, sub-oppositely 2-bracted below the middle with ovate scale-like ciliate and glandular bracts scarcely 2.5 mm. long, appressed or spreading short-hairy. Sepals caducous, ovate, obtuse, about 2.5 mm. long and 2 mm. broad, ciliate, glandular-punctate on the back, very similar to the bracts. Petals broadly oblanceolate, about 10 mm. long and 4 mm. broad, very obscurely glandular. Stamens distinctly in two series, the filaments of the inner series (opposite the petals) 2 or rarely 3 mm. long, those of the outer series (opposite the sepals) 4 mm. long. Ovary 2 to 3 mm. long and 1.5 to 2 mm. broad at anthesis, distinctly lobed and the lobes gland-tipped, densely pubescent except the tips; style about 1 mm. long, often only 0.5 mm. projecting beyond the ovary. Fruit of 2 or 3 carpels, about 6 mm. long, sparsely hairy and saliently punctate-glandular.

*Type locality*—"Mountains about thirty-five miles below El Paso, in Chihuahua, Mexico."

MEXICO—CHIHUAHUA: the "Flounce Mountains," *Bigelow* without number or date (US, F, NY—type and several duplicates—this material was distributed under the U. S.-Mexican Boundary Survey no. 146, is made up of several collections from several localities in Texas, New Mexico, and Chihuahua, and in various herbaria was ascribed to various collectors, notably to A. Schott).

UNITED STATES—NEW MEXICO: Doña Ana County, Organ Mts., *Pope* without number or date (US, NY—another element in the U. S.-Mexican Boundary Survey no. 146); N.E. corner Jornada Range, Sept. 8, 1912, *E. O. Wooton* without number (US, NY); San Andreas Mts., Feb. 9, 1902, *E. O. Wooton* without number (US); Jan. 1907, *E. O. Wooton* without number (US); May 23, 1913, *E. O. Wooton* without number (US); Sheep Mt., San Andreas Mts., Dec. 21, 1902, *J. H. Gant* 37 (US); Sierra County, Rio Mimbres, 1854, *Henry* without number (NY); Otero County, Alamogordo, April 7 to May 24, 1902, *J. A. G. Rehn* and *H. L. Viereck* without number (US, NY); Eddy County, 40 miles southwest of Carlsbad, April 30, 1924, *D.W. Lee* 82 (US); Carlsbad Cavern, April 1924, *V. Bailey* without number (US).—TEXAS: without locality, May to Oct. 1849, *C. Wright* (1321)(G); Sept. 28, 1881, *V. Havard* 1064 (US, NY); *A. Schott* without number or date (US, NY, G—"Pope's 1st Exped., Texas"); Culbertson County, foothills of Guadalupe Mountains, Oct. 1881, *V. Havard* 39? (M); Guadalupe Mountains, Aug. 18, 1916, *M. S. Young* without number (G, M); Guadalupe Mountains, Pine Canyon, Aug. 15 to 17, 1924, *P. C. Standley* 40582 (US); May 29 to June 4, 1912, *A. Chase* 5995 (US); Guadalupe Mountains, Sitting Bull Falls, Aug. 12 to 20, 1924, *P. C. Standley* 40736 (US); Guadalupe Mountains, McKittrick Canyon, Aug. 15 to 17, 1924, *P. C. Standley* 40501 (US); McKittrick Canyon, July 21, 1931, *J. A. Moore* and *J. A. Steyermark* 3552 (US, NY, AA, M, UC, S); Brewster County, Sept. 5, 1925, *B. C. Tharp* 3486 (US).

The range of *C. dumosa* is closely restricted in an area comprising southern New Mexico, Trans-Pecos Texas, and northwestern Chihuahua. It is doubtful that any great extensions of this range will ever be made.

4. *Choisya arizonica* Standl., Proc. Biol. Soc. Wash. 27:222. 1914

*C. dumosa* of authors—as to Arizona material. Not *C. dumosa* A. Gray.

Twigs densely strigose to sparsely puberulent, prominently warty with raised glands and these often evident for years. Leaves 3- to sometimes 5-foliolate, the leaflets 20 to 50 mm. long, 1 to 2 or rarely 3 mm. broad, apically glandular-emarginate, basally narrowed, the margins glandular-subdentate, glabrate or sparingly appressed-hirtellous especially along the midrib above; petioles 3 to 10 or even 15 mm. long but always less than one-third the length of the leaflets, appressed-hirtellous especially at the apex, sparsely raised-pelucid-glandular. Flowers solitary in the axils of the leaves, crowded toward the tips of the stems, pedicels 10 to 20 mm. long, suboppositely bracteate above or below the middle with ciliate and dorsally pubescent ovate bracts 1.5 to 2 mm. long, appressed- or spreading-hirtellous. Sepals ovate, obtuse, 2.5 to 3 mm. long, 2 mm. broad, ciliate, sparsely hirtellous and pelucid-glandular on the back, rather persistent. Petals 9 or 10 mm. long, 4 or 5 mm. broad, narrowly obovate or elliptic, sparsely pelucid-glandular. Stamens 3.5 to 5 mm. long, the inner series (opposite the petals) as large as the outer or somewhat smaller. Ovary about 2 mm. long and nearly as broad at anthesis, densely strigose except the glabrous tips of the lobes; styles 1 to 1.5 mm. long, scarcely projecting beyond the lobes of the carpels. Fruit similar to that of *C. dumosa*.

*Type locality*—Santa Rita Mountains, Arizona.

UNITED STATES—ARIZONA: Cochise County, Bisbee, May 31, 1915, *J. I. Carlson* without number (US, AA); mountains near Bisbee, May 23, 1928, *R. H. Peebles* 5355 (US); Mule Mountains, July 20, 1894, *J. W. Toumey* without number (US, NY, G, M, UC); May 4, 1931, *S. D. McKelvey* 2113 (AA, UC); *S. D. McKelvey* 2115 (US); Sept. 20, 1929, *G. J. Harrison* and *T. H. Kearney* 6100 (US); Tombstone Canyon, Mule Mountains, April 30, 1933, *F. Shreve* 6279 (F, S); Dragoon Mountains, June 1899, *J. H. Eby* without number (M); July 16, 1919, *A. Wetmore* 676 (US); Cochise Stronghold Ranger Station, Coronado National Forest, April 4, 1929, *S. B. Detweiler* 64(?); Pima County, Santa Rita Mountain, May 16, 1884, *C. G. Pringle* without number (US—type as sheet no. 15060, NY, G, AA, F, M); Mustang Mountains, June 28, 1884, *C. G. Pringle* without number (US, NY, G, AA, F).

The few, elongate leaflets, shortpetioles, and less salient glands set this species off distinctly from *C. dumosa*. Yet, the relationship between the two is very close, and no other species so nearly approaches *C. dumosa* as does *C. arizonica*. The former species is confined to southern New Mexico, Trans-Pecos Texas, and northwestern Chihuahua, while *C. arizonica* is known only from southern Arizona. No intermediates have been observed.

5. **Choisya Katherinae** sp. nov.

Folia 4- usque 7- vel 8-foliolata, foliola linearia 18-30 mm. longa 1.5-2 mm. lata basi angusata minute strigosa revoluta glanduloso-subdentata, petioli 12-25 vel raro 35 mm. longi glandulosi strigosi; flores solitarii axillares, pedicelli 15-30 vel rare 40 mm. longi dense pubescentes, sepala ovata obtusa 2-3 mm. longa sericea, petala oblanceolata obtusa 10-13 mm. longa, stamina 3.5-4.5 mm. longa, fructus eis *C. dumosae* similes.

Fig. 5. *Choisya Katherinae* C. H. Mull. Fig. 6. *Choisya Palmeri* Standl.

Twigs sparsely and inconspicuously papillsoe-glandular, persistently strigose for several years. Leaves 4- to usually 7- or 8-foliolate, the leaflets linear, about 18 to 30 mm. long and 1.5 to 2 mm. broad, occasionally much shorter on the same branch, apices rounded or sometimes emarginate, gradually much narrowed basally, the margins revolute, rather inconspicuously raised-glandular, minutely densely curved-strigose, the hair-tips usually bent into contact with the epidermis, pubescence evenly distributed over both surfaces or the lower surface sometimes glabrate; petioles 12 to 25 or rarely 35 mm. long, in any event two-thirds as long as the leaflets or much longer, rather inconspicuously raised-glandular, strigose. Flowers solitary in the axils of the leaves, usually crowded toward the tips of the branches, pedicels 15 to 30 or rarely even 40 mm. long, suboppositely bracteate above or below the middle, rather densely short-spreading- or appressed-pubescent, the bracts caducous, oblong, obtuse, about 2.5 mm. long, densely sericeous all over. Sepals ovate, obtuse, 2 to 3 mm. long, densely sericeous on both surfaces, sparingly glandular on the back. Petals oblanceolate, obtuse, about 10 to usually 12 or 13 mm. long. Stamens 3.5 to 4.5 mm. long, in two not markedly different series. Ovary about 2.5 mm. long and 2 mm. broad at anthesis, densely white-strigose all over except the glabrous glandular carpel tips; style projecting about 0.5 mm. Fruit similar to that of *C. dumosa*.

MEXICO—COAHUILA: Municipio de Cuatro Cienegas, Sierra de la Madera, Cañon del Agua, Sept. 10, 1939, *C. H. Muller* 3245 (NA—type as sheet no. 71427); Municipio de Sierra Mojada, Sierra Mojada, April 20, 1892, *M. E. Jones* 21 (US, NY, UC, S).

*Choisya Katherinae* is known only from central and west-central Coahuila in the isolated mountain ranges of Sierra de la Madera and Sierra Mojada. This distribution lies directly south of that of *C. dumosa* and far to the east of that of *C. arizonica*, the two species to which this is most closely related. From *C. dumosa* it is readily distinguished by its lack of extremely prominent glands on the leaf margins, petioles, and stems, the persistence of curved strigose hairs on the upper leaf surface, the leaves strikingly narrowed basally, and the usually elongate pedicels. From *C. arizonica* this species is distinguished by its less prominent glands, longer petioles, and more numerous leaflets. *C. Katherinae* is a densely leaved shrub from 0.3 to 1 m. tall with slender, graceful, erect branches. This species is named in honor of Mrs. Katherine K. Muller whose efforts contributed greatly to the success of the expedition on which this collection was made.

6. *Choisya Palmeri* Standl., Proc. Biol. Soc. Wash. 27:224. 1914

Twigs nearly eglandular, very sparsely raised-glandular, densely short-spreading-hirsute and remaining scurfy for years. Leaves 5- to 8- or rarely 10-foliolate, the leaflets linear, about 8 to 18 or rarely 30 mm. long and uniformly 1 to 1.5 mm. broad, narrowed abruptly at the base, tending to be fastigiate, emarginate, the margins markedly revolute, obscurely raised-glandular, copiously short-hirsute all over, the hairs rather uniformly straight and spreading; petioles 7 to 15 or even 20 mm. long, at least half as long as the leaflets,

obscurely raised-glandular, copiously short-spreading-hirsute. Flowers solitary in the axils of the leaves, crowded toward the tips of the stems, pedicels 5 to 25 mm. long, suboppositely bracteate at nearly any point along their length, moderately short-spreading-hirsute; bracts caducous or somewhat persistent, narrowly ovate, obtuse, sericeous all over, apparently eglandular. Sepals narrowly ovate to oblong, obtuse, moderately pubescent. Petals oblanceolate, obtuse, 8 to 10 mm. long, about 3 to 3.5 mm. broad, inconspicously glandular. Stamens 3 to 5 mm. long, the inner series (opposite the petals) obviously smaller. Ovary about 2.5 mm. long and 2 mm. broad at anthesis, copiously strigose except the glabrous glandular tips of the lobes; style protruding about 0.5 mm. beyond the apex of the ovary. Fruit of 3 or 4 carpels, 5 or 6 mm. long, copiously glandular and densely spreading-hirsute.

*Type locality*—Chojo Grande, 27 miles southeast of Saltillo, Coahuila.

MEXICO—COAHUILA: Chojo Grande, 27 miles southeast of Saltillo, July 16, 1905, *Edw. Palmer* 715 (US—type as sheet no. 570236, NY, G, F, M, UC); mountains 6 miles east of Saltillo, July 17 to 20, 1880, *Edw. Palmer* 139 (G, M); Sierra Pata Galana, southeast of Parras, Feb. 1905, *C. A. Purpus* 1034 (NY, G, F, M, UC).—ZACATECAS: high mountains, Cedros, northern Zacatecas, 1908, *F. E. Lloyd* 61 (G); Pico de Teira, May 17, 1908, *F. E. Lloyd* 223 (US).

*Choisya Palmeri* is clearly distinct from all other known species in its uniformly narrow and deeply revolute leaves, copious short-spreading pubescence, and sparsely glandular parts. The species is not very closely related to any other, but its affinity is with *C. Katherinae* and *C. mollis* although it shows no marked resemblance to either. Its restricted range in extreme southern Coahuila and northern Zacatecas is the most remotely isolated of any species of the *Astrophyllum* group.

7. *Choisya mollis* Standl., Proc. Biol. Soc. Wash. 27:223. 1914

Twigs sparsely but conspicuously papillose-glandular, copiously spreading-hirsute, remaining scurfy for several years. Leaves 3- to usually 5-foliolate, the leaflets 20 to 45 mm. long and 2 to usually 3 or 5 mm. broad, linear but narrowed at both ends, obtuse or emarginate, the margins revolute, midrib impressed above and prominent beneath but the blades otherwise thin and flat, minutely repandly glandular-toothed, copiously spreading-sericeous-pilose all over; petioles 5 to 15 mm. long, distinctly papillose-glandular, copiously hirtellous. Flowers solitary in the axils of the leaves, crowded toward the tips of the stems; pedicels 15 to 20 mm. long, moderately spreading-hirsute, suboppositely bracteate near the middle. Sepals broadly ovate, obtuse, hirsutely ciliate, sparsely strigose and glandular-punctate on the back. Petals and stamens not seen. Ovary about 2.5 mm. long and 2.5 mm. broad at anthesis, densely white-strigose save the glabrous glandular tips of the lobes; style protruding about 1 mm. Fruit not seen.

*Type locality*—Western slope of Sierra del Paparito, Santa Cruz County, Arizona.

UNITED STATES—ARIZONA: Santa Cruz County, western slope of Sierra del Pajarito, 1854, *A. Schott*, as Boundary Survey no. 146 (US—type as sheet no. 15062, NY,

Fig. 7. *Choisya mollis* Standl.

F); mountains between Ruby and the Tucson-Nogales Highway, March 15, 1935, *A. Nelson* and *R. A. Nelson* 1192 (NY); Sycamore Canyon (near Ruby), Sept. 24, 1939, *T. H. Kearney* and *R. H. Peebles* 14456 (US).

*Choisya mollis* differs widely from the other species of the *Astrophyllum* group in its broader leaves suggesting those of *Salix taxifolia,* its densely pilose vesture, and its hirsutely ciliate sepals. Its restriction to Santa Cruz County, Arizona, constitutes a smaller range than that of any other well known species.

The type locality was given by Standley as "Sierra del Pajarito, Sonora," which was not true at the time of the collection of the type in 1854, for the Gadsden Purchase of 1853 transferred this area to Arizona. Schott in a letter to Torrey reported having collected what he thought was *Astrophyllum dumosum* in Sonora. That Standley was right in assuming that the *C. mollis* element on the mixed sheets of Boundary Survey no. 146 represented Schott's collection is shown by the subsequent collection of the same form in close proximity to Schott's locality by Nelson and Nelson in 1935 and by Kearney and Peebles in 1939.

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# Three Species Pairs from Southern and Lower California

Harlan Lewis and Carl Epling

The two principal and characteristic climax formations of coastal southern California and adjacent Lower California are the chaparral and coastal sage. Their distributional relationship suggests for both a similar historical development. The occurrence within each formation of several species pairs, one member of which has a more northerly distribution, usually in California, the other a more southerly distribution, usually in northwestern Lower California, suggests either that there have been two centers of speciation within these formations or that during their development a segregation of closely related forms has taken place. The purpose of this paper is to describe three of these pairs. The members of two pairs have long been recognized in the manuals as varietally different, but have never been clearly differentiated; one member of the third pair has only recently been discovered.

The authors are indebted to the curators of the following herbaria for loan of material: the University of California at Berkeley, Stanford University, the California Academy of Sciences, the San Diego Museum of Natural History and Pomona College. They are indebted to Project No. C-11775-2 of the Federal Works Progress Administration for clerical assistance, the photographs and drawings.

### 1. **Fraxinus trifoliata** Lewis & Epl. comb. nov.

*Fraxinus dipetala* H. & A. var. *trifoliata* Torr. Bot. Mex. Bound. 167. 1849.

Shrub, 2-4 m. tall, with slender erect branches; leaves simple, the blade 1.5-3.5 cm. long, or more commonly compound with 3 leaflets, the terminal 2.0-4.0 cm. long, 1.0-2.5 cm. broad, the lateral leaflets smaller, 1.0-2.5 cm. long, 0.5-1.5 cm. broad, all obtuse at the apex, subentire, the petiole slender, 1-2 cm. long; flowers numerous, in panicles 3-10 cm. long; calyces 1.25-2 mm. long, shallowly 4-lobed; corolla cream color, tubular by fusion with the filaments, the tube 0.6-1.5 mm. long, the petals two, 4.5-6.5 mm. long, including the tube, 2.2-4.3 mm. wide; stamens 2.7-4.7 mm. long above fusion with petals; stigma 0.6-1.4 mm. long, style 0.7-1.3 mm. long; samaras 2-3 cm. long, 7-9 mm. wide, oblanceolate.

Distribution (Fig. 1).—Baja California. N. E. of Aguajita Spring, *Harbison 14986*. Sacaton Grade, *D. R. Harvey 523*. 25 mi. E. of San Telmo, *A. Meling 29*. Valley of the Palms, 8-IV-82, *Jones*. Ensenada, *Anthony 188*. Punta Banda, 16-XII-27, *Jones*. San Antonio Canyon 7 mi. above Johnson Ranch, 17-II-35, *Epling and Robison*. Aliso, 1-V-93 *Brandegee*. 5-6 miles east of Ensenada on road to Ojos Negros, *Wiggins and Gillespie 4030*. Between San Jacinto Rancho and Santo Tomas, *Wiggins 4552*. Near San Vicente, 17-IV-25 *Jones*. Guatay Grade, 24 miles N. of Ensenada, *Wiggins and Gillespie 3981A*. Santo Tomas to Santa Cruz, 18-II-35, *Epling and Robison*. Carrizo Creek, Valle de la Trinidad, *Harbison 14974*; 18-IV-93, *Brandegee*.

In Table 1 are contrasted the several characters which seem to be of specific distinction.

From the table and from Fig. 2 it will be seen that *Fraxinus trifoliata* and *F. dipetala* are sharply differentiated by the leaflet number and the corolla tube. Apart from these distinctions they differ in various degrees in all proportions of the flower and leaf. In the habit of the whole plant they are similar, although careful comparisons would doubtless demonstrate differences of the same order. One may occasionally find trifoliate leaves on *F. dipetala* but the lateral leaflets are then usually approximately the same size as the terminal leaflet rather than being one-half to two-thirds the size of the terminal leaflet as in *F. trifoliata*. The leaves may be further distinguished by the leaf margins, which are regularly serrate in *F. dipetala*, at least in the upper half, and entire or weakly serrate in *F. trifoliata*.

The flowers of *F. trifoliata* are distinguished by the presence of a distinct tube, formed by the fusion of the petals and filaments, while in *F. dipetala* the petals and filaments are separate or but slightly joined at the base. Occasionally

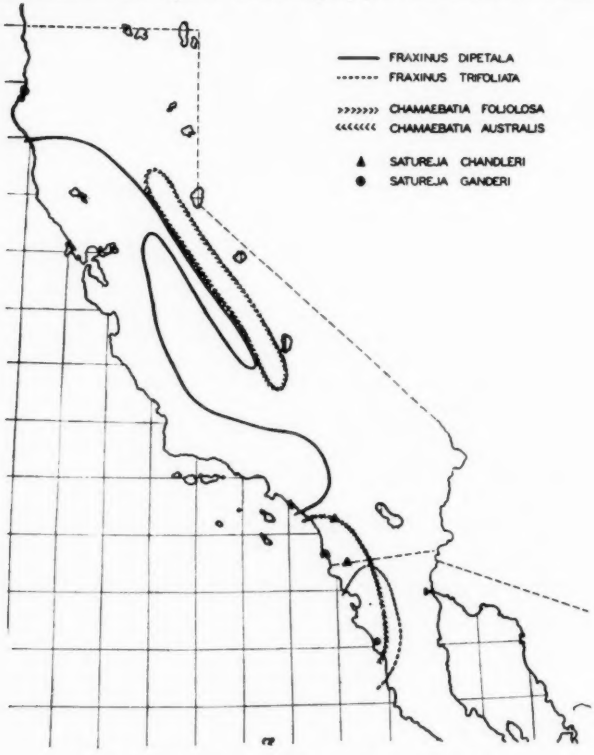



Fig. 1. Distribution in outline of the species pairs.

TABLE 1

| | *F. trifoliata* | *F. dipetala* |
|---|---|---|
| LEAVES (measurements in cm.) | n = 21 | n = 50 |
| Average length (incl. petiole) | 4.5 | 11.2 |
| Number of leaflets | 1-3 | (3) 5-9 |
| Length terminal leaflet | 2.0-2.5-4.0* | 2.0-2.7-4.0* |
| Width terminal leaflet | 1.0-1.7-2.5* | 1.0-1.7-2.5* |
| Ratio of length to width | 1.5:1 | 1.6:1 |
| Length lateral leaflet | 1.0-1.6-2.5* | 2.0-2.7-4.0* |
| Width lateral leaflet | 0.5-0.9-1.5* | 1.0-1.4-2.2* |
| Ratio of length to width | 1.8:1 | 1.9:1 |
| Ratio of length of terminal to lateral leaflets | 1.5:1 | 1:1 |
| Margin of leaflets | subentire | serrate |
| FLOWER (measurements in mm.) | n=12 | n = 25 |
| Length of calyx | 1.25-1.5-2.0* | 1.25-1.4-2.0* |
| Length of petals | 4.5-5.5-6.5* | 3.5-5.0-6.5* |
| Width of petals | 2.2-3.3-4.3* | 1.3-2.2-3.0* |
| Ratio of length to width | 1.6:1 | 2.2:1 |
| Fusion of filaments and petals | Fused into tube: 0.6-1.0-1.5* long | Fused lightly at base, rarely forming a tube |
| Filament length above fusion | 0.4-0.6-1.0* | 0.8-1.8-2.8* |
| Anther length | 2.3-3.2-3.8* | 2.4-3.1-4.2* |
| Ratio of length of anther to length of filament | 5.0:1.0 | 1.8:1 |
| Style — length | 0.7-0.96-1.3* | 0.6-0.88-1.1* |
| Stigma — length | 0.6-0.84-1.4* | 0.4-0.61-1.3* |
| Ratio of length of style to length of stigma | 1.0:1 | 1.4:1 |

* Minimum, Average, Maximum.

in the latter a filament may be partially fused with one of the petals and one specimen was observed where the fusion formed a complete tube, but even then not to the extent to which the tube in *F. trifoliata* is developed. The petals of *F. trifoliata* are larger, rounder, and of a thicker texture than the spatulate petals of *F. dipetala*. The stigma in *F. trifoliata* is about the same length as the style; in *F. dipetala* it is usually only two-thirds the length of the style. The samaras are not noticeably different.

Two specimens, one a sterile shoot from Mt. Diablo, Contra Costa County, *McMinn 407*, and the other, a fruiting specimen from Smartsville, Nevada County, *Josephson 44*, probably represent extremes of *F. dipetala*. They have very large, thick, leathery leaflets, 6 cm. long and 4 cm. wide. A third specimen without flowers from the Santa Lucia Mountains, Monterey County, 4-VIII-26, *Dudley*, is also probably *F. dipetala*. The leaflets are of normal size but are quite round, subentire and on leaves that are crowded at the ends of the twigs.

The leaves of *F. macropetala* Eastw. of northwestern Arizona are very similar to those of *F. trifoliata* but that species is readily distinguished from *F. trifoliata* by its long, tubular, four-lobed corolla.

*F. trifoliata* does not usually occur within typical chaparral but is generally peripheral or associated with, but apparently not genuinely a part of, the coastal sage. *F. dipetala* is more genuinely a part of the chaparral. Neither is known from San Diego County.

Distribution of *F. dipetala* (Fig. 1).—CALIFORNIA. Butte, Calaveras, Contra Costa, Fresno, Lake, Los Angeles, Mariposa, Merced, Monterey, Napa, Nevada, Orange, Riverside, San Benito, San Bernardino, San Luis Obispo, Santa Barbara, Santa Clara, Stanislaus, Tehama, Tulare, Tuolumne, and Ventura Counties.

2. *Chamaebatia australis* Abrams in Bull. Torr. Bot. Club 34:263. 1907
*C. foliolosa* var. *australis* Brand. in Bot. Gaz. **27**:447. 1899.

Although Abrams made this combination more than 30 years ago, the manuals in current use still refer to this plant as *Chamaebatia foliolosa* Benth. var. *australis* Brandg., perhaps because it was not clearly differentiated.

In addition to the available herbarium material of *C. australis*, field samples were taken at Potrero Grade in San Diego County and on Pine Ridge, 6 miles southwest of San Vicente, Baja California. Herbarium material alone was used in studying *C. foliolosa*.

Distribution of *C. australis* (Fig. 1).—CALIFORNIA. San Diego County: Potrero Grade, San Miguel Mt., Otay Mt., and 7 miles N.E. of Fallbrook.—BAJA CALIFORNIA. San Ysidro Ranch, *Mearns 3861*. 15-20 miles east of Ensenada on road to Ojos Negros, *Wiggins and Gillespie* 4049. La Grulla, 17-V-86, *Orcutt*. Tecate River near Monument 245, *Mearns and Schoenefeldt* 3761. Monument 246, I—03, *Stephens*. Pine Canyon, 6 miles S. W. of San Vicente, 27—III—40, *Epling and Robison*.

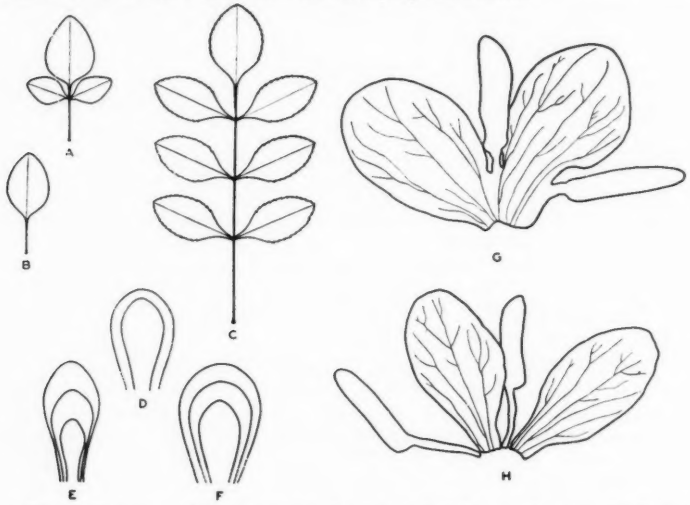



Fig. 2. Drawings which summarize the principal differences between *F. dipetala* and *F. trifoliata*. A, mean leaf of *F. trifoliata*, summarizing measurements of 21 specimens and observations of habit. B, Occasional or frequent simple leaf of that species. C, Mean leaf of *F. dipetala*, summarizing measurement of 50 specimens. Occasional trifoliate leaves of similar habit may be found. D, Contrasted means of petal measurements, the smaller, *F. dipetala*. E, *F. dipetala*. Minimum, mean and maximum measurements of petals. F, *F. trifoliata*. Minimum, mean and maximum measurements of petals. G, Camera lucida drawing of a flower of *F. trifoliata*. H, Camera lucida drawing of a flower of *F. dipetala*.

Distribution of C. *foliosa* (Fig. 1).—CALIFORNIA. Amador, Calaveras, Eldorado, Fresno, Mariposa, Nevada, Placer, Shasta, Sierra, Tulare, Tuolumne and Yuba Counties.

In the field the most striking difference is observed in the habit and size of the two plants. *C. australis* is a woody rounded shrub, for the most part nearly 2 meters high, in contrast to the low creeping habit of *C. foliolosa* that is usually .5 meter high or less. In the herbarium they may be readily distinguished by other characteristics, particularly the leaves. As may be seen from Table 2 and Figures 3 and 4, there is a marked difference in the number of leaflets. *C. australis* is only twice or weakly thrice pinnate, *C. foliolosa* is never twice and is occasionally 4 times pinnate.

Both plants are glandular pubescent, and although there is some variation, there is constantly less hair in *C. australis*. In that species it is largely confined to the rachis and mid-ribs; in *C. foliolosa* it is quite evenly distributed. At the apex of each leaflet is a gland which is stalked in the northern species and sessile or depressed in the southern species.

The flowers in the two species are similar and sufficiently variable so that the sizes of the flower parts overlap, but there is an appreciable difference in the averages. The calyces and petals are smaller in *C. australis* and the stamens

TABLE 2

| | *C. foliolosa* | *C. australis* |
|---|---|---|
| Height | 2-6 dm. | 1-2.5 m. |
| Measurements in cm. | n = 50 | n = 19 |
| Leaf shape | Obovate | Elliptical |
| Leaf length | 3.5-5.5-10 * | 3.5-5.0-8.0* |
| Leaf width | 2.0-3.2-7.0* | 1.2-1.7-2.7* |
| Ratio of length to width | 1.7:1 | 2.9:1 |
| Number of times pinnate | 3 (occasionally 4) | 2-3 |
| Number of primary divisions (including terminal segment) | 10-12-16* | 14-19-24* |
| Number of secondary divisions (including terminal segment) | 7-10-13* | 7-9-12* |
| Number of tertiary divisions (including terminal segment) | 4-5-8* | 1-3-5* |
| Stalked glands and hairs | Uniformly covering the leaf | Fewer, largely confined to to midribs and rachis |
| Apical glands | Stalked | Sessile or somewhat sunken |
| Measurements in mm. | n = 15 | n = 14 |
| Length of calyx lobes | 3.5-4.6-6.0* | 2.5-3.0-4.0* |
| Length of calyx tube | 3.0-3.8-4.5* | 2.0-3.0-4.0* |
| Ratio of length of lobes to length of tube | 1.2:1 | 1:1 |
| Length of petals | 5.0-7.2-9.0* | 4.0-5.7-7.0* |
| Width of petals | 4.0-5.5-7.0* | 4.0-5.0-7.0* |
| Ratio of length to width | 1.3:1 | 1.2-:1 |
| Number of stamens | 50-70 | 40-50 |
| Length of stigma and style | 3.8-4.5-5.5* | 2.1-3.5-4.5* |
| Ovary | Hairy | Glabrous |

* Minimum, Average, Maximum.

are fewer in number. The combined length of the stigma and style is shorter in *C. australis* and the ovary is glabrous rather than pubescent.

*C. foliolosa* forms a widespread and abundant ground cover in the Yellow Pine forest of the Sierra Nevada. *C. australis* is a good member of the chaparral, associated with *Arctostaphylos pungens, Ceanothus tomentosus* var. *olivaceus* (seemingly specifically distinct from *C. tomentosus*), *Cercocarpus minutiflorus, Rhus integrifolia, Rhus laurina, Photinia arbutifolia, Quercus dumosa, Adenostoma fasciculatum* var. *obtusifolium* and *Rhamnus crocea.*

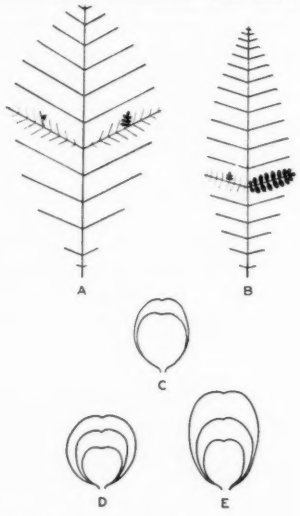



Fig. 3. A, Branching habit of a mean leaf of *Chamaebatia foliolosa*. On the left center branch, the maximum branching, on the right, the minimum branching observed, together with leaflet number. B, *C. australis*, the same. C, Contrasted means of petal size, the larger, *C. foliolosa*. D, Minimum, mean and maximum petal size of *C. australis*. E, *C. foliolosa*, the same.

3. **Satureja Ganderi** Epl. sp. nov. (Xenopoma)

Herba perennis fragrans stolonifera sat ramosa altitudine fere ad 2 m. ramulis superne pilis brevibus decurvis sparse hirtellis, internodiis magnam partem folia subequantibus vel brevioribus; foliorum laminis viridibus ovatis 8-15 mm. longis in apice obtusis infra medium rotundato-angustatis etiam subcuneatis, marginibus subcrenatis, paginis ambabus fere glabris inferiore pallidiore; petiolis 5-10 mm. longis; floribus in foliorum supremorum axillis modo solitariis modo tribus in cymulis breviter bracteolatis pedunculis 2-3 mm. longis elatis dispositis; calycum 7-8 mm. longorum extus sparse hispidulorum labia superiore 2-2.5 mm. alta ad medium et ultra connatis, laciniis acuminatis erectis, inferiore aequilonga, laciniis liberis; corollarum dorsaliter pallide violacearum tubo 10 mm. longo intus fere glabro faucibus tamen hirtellis, laciniis circiter 2 mm. diametro; staminibus ad fauces positis lacinias subaequantibus; stylo hispidulo.

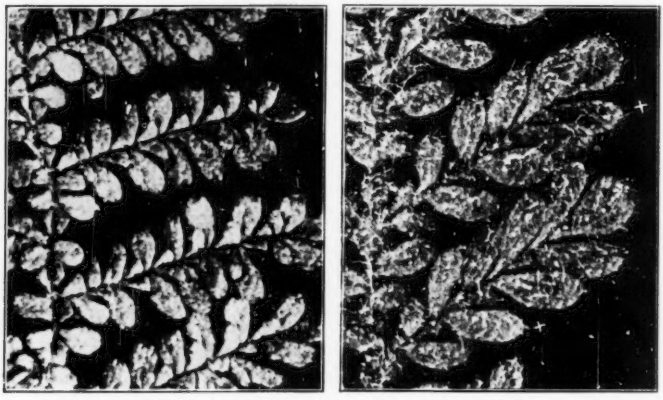
In angustiis Canon de Pinitos dictis ad vicum San Vicente in Baja California septentrionale, *Epling et Lewis* (U. C. L. A., typus).

It is a privilege to associate with this attractive plant the name of Mr. Frank Gander, Curator of the Herbarium of the San Diego Museum of Natural History and an acute student of the Diegan flora. Mr. Gander not

only introduced me to the rare *Satureja Chandleri*, the ally of this species, but bringing both species under cultivation, called my attention to the differences between them. I am indebted to Senora Elisa Guzman y Olachea of Santo Tomas who first pointed out to me this native "poleo." It is only known from Pine, and Cypress canyons near San Vicente and from a lateral canyon of the Rio San Antonio above the Johnson ranch. It occurs in the canyon bottoms more nearly in association with chaparral species than with those of the *Artemisia-Salvia* association. It may be expected in the canyon bottoms northward toward Punta Banda near Ensenada.

*S. Chandleri* may be distinguished by the marked pubescence, the broader deltoid-ovate leaves and the wholly white corolla. Its calyces are characteristic in that the lobes are equally reflexed at anthesis, giving a star-like appearance to the orifice, while those of *S. Ganderi* remain more nearly erect after the habit of most of *Calamintha* or *Hedeoma*. The corolla tube is broader and the limb more spreading with a distinctly different conformation when seen fresh. Both species are referable to the section *Xenopoma* and both are very similar in habit and pubescence to *S. brevicalyx* Epl. and *S. vana* Epl., both species of Peru. The flowers of these are smaller, but the habit of calyx of the first-named is suggestive of that of *S. Chandleri*.

*S. Chandleri* is known only from San Miguel Mountain, near San Diego and from a canyon near Murietta, California.



A B

Fig. 4. Photographs of leaves of *Chamaebatia australis* (A, ×10) and *C. foliosa* (B, ×20) enlarged. The rhachis of the leaf of the former is the primary one; that of the latter, a secondary one. The sunken glands may be seen at the tips of the leaflets of A. In addition to trichomes, stalked glands may be seen on the leaflets of B, as indicated by the crosses.

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# Verbenaceous Novelties

Harold N. Moldenke

Continued monographic studies on the *Verbenaceae* have revealed a number of new species, varieties, and forms in this group from the United States and four apparently undescribed cultivated varieties frequently seen in this country. These will all be fully discussed in my forthcoming generic monographs, but since these monographs may not be published for some years, it has been thought advisable to present the formal diagnoses and abbreviated descriptions at this time.

**Clerodendrum trichotomum** var. **tomentosum** Moldenke, Geogr. Distrib. 38, nom. nud. (1939), var. nov.

A forma typica pilis ubique dense tomentosis, non tantum puberulis vel strigilloso-pubescentibus recedit.

This variety differs from the typical form of the species in being tomentose throughout, instead of merely puberulent or strigillose-pubescent. The branchlets and petioles are very densely tomentose with short white or cinereous multicellular hairs. The peduncles, inflorescence-branches, pedicels, and bracts are likewise cinereous- or albidous-tomentose with multicellular hairs, although more sparsely so. The lower leaf-surface is densely tomentose (like the branchlets) on the midrib and secondaries and more lightly so on the vein and veinlet reticulation. The upper leaf-surface is sparsely strigillose throughout or often densely fufuraceous on the midrib and secondaries. The calyx is lightly pubescent.

The type of this variety was collected by Edwin Bingham Copeland from a cultivated plant on the Plant Introduction Grounds at Chico, California, in September, 1931, and is deposited in the herbarium of the University of California at Berkeley. The original seed is said to have come from China. The same variety has also been collected in cultivation in Bucks Co., Pennsylvania.

**Verbena Abramsi** sp. nov.

Herba, ad basin lignosa; caulis ramisque gracilibus dense hirsutis; foliis sessilibus oblanceolatis vel obovatis irregulariter inciso-dentatis, ad basin cuneatis, supra strigosis scabris, subtus dense strigoso-pubescentibus vel subhirsutulis; inflorescentiis spicatis terminalibus; spicis elongatis gracilibus post anthesin laxifloris; calyce parvissimo minute dentato.

Herb, often somewhat woody at base; stems erect or branching from the base and prostrate-ascending, slender, tetragonal, usually thick-margined on the

angles, densely short-hirsute with brownish or canescent hairs issuing at right angles to the stem, less so in age; branches similar to the stems, but even more densely and persistently short-hirsute; leaves sessile, oblanceolate or obovate, 1.5-9.5 cm. long, 0.5-3.5 cm. wide, usually small, dark green on both surfaces, often brunnescent in drying, acute at apex, cuneate at base, irregularly incised-dentate except at the cuneate base, sometimes the 2 lowermost divisions lobe-like, densely short-strigose with closely appressed hairs and scabrous or subscabrous above, densely strigose-pubescent or subhirsutulous beneath; inflorescense spicate, terminal; spikes elongate, to 12 or more cm. long, slender, about 5 mm. wide, dense before anthesis, loosely many-flowered after anthesis, the fruiting-calyxes not imbricate; bractlets ovate, about 2 mm. long, acute at apex, densely hirsutulous-pubescent; calyx very small, 2-3 mm. long in all, densely hirsutulous, its rim very minutely toothed with very short and obscure apiculate teeth; corolla-tube about 4 mm. long, its limb about 2.5 mm. in diameter.

The type of this distinct species was collected by Edward Palmer (no. 309) at Hot Springs, in the southern part of San Diego Co., California, in 1875, and is deposited in the Morong Herbarium of Barnard College at New York Botanical Garden. The species is known also from Inyo, Kern, Los Angeles, Mariposa, Monterey, Riverside, Sacramento, San Bernardino, and Tulare Counties. It has in the past been confused with *V. lasiostachys* Link, from which its small and minutely toothed calyxes at once distinguish it. It is named in honor of the distinguished California botanist, Dr. LeRoy Abrams, who collected it in the San Gabriel Mountains at an altitude of 3,000 feet.

**Verbena Cloveri** sp. nov.

Herba, ad basin lignosa, a basi ramosa; ramis acute 4- vel 5-angulatis dense breviterque villosis eglandulosis; petiolis ad basin late alatis; laminis firmis plerumque ovatis crasse et irregulariter inciso dentatis vel versus basin 3-lobatis, supra breviter obscureque puberulis, subtus densiore breviterque pubescentibus; venis supra impressis, subtus valde prominentibus; bracteolis lanceolatis.

Herb, woody at base, branching from near the base; branches rather sharply 4- or 5-angled, densely short-villous, the hairs standing at right angles to the branches, not gland-tipped; leaves petiolate, the petioles 0.5-1.5 cm. long, broadly winged to the base; blades rather firm, resembling those of *V. plicata*, mostly ovate in outline, those on the main branches 1.5-3 cm. long, 1-2.5 cm. wide, coarsely and irregularly incised-dentate or shallowly 3-lobed toward the base, shortly and obscurely puberulent above, more densely short-pubescent (especially along the larger venation) beneath; the entire venation impressed above and very prominent and whitish beneath as in *V. plicata;* leaves in the inflorescence small, sessile or subsessile to shortly winged-petiolate, sharply and coarsely incised-dentate or lobed, firm and rather stiff, rapidly decreasing in size upwards; spikes 8-25 cm. long; bractlets lanceolate, stiff, the lowermost to 7 mm. long, the uppermost 2.5-3 mm. long, shorter than the calyx in anthesis; calyx 4-4.5 mm. long, prominently 4-ribbed, the ribs hirsute like the branches, purplish as in *Stylodon carneus* before and during anthesis; flowers about the

size of those of *Stylodon carneus,* to about 12 mm. long; corolla-tube far exceeding the calyx, 8 or more mm. long, the limb 7-8 mm. in diameter.

The type of this species was collected by Elzada Urseba Clover (no. 1618) —in whose honor it is named—four miles north of Rio Grande City, Starr Co., Texas, on January 11, 1934, and is deposited in the Britton Herbarium at the New York Botanical Garden.

**Verbena Demareei** sp. nov.

Herba a basi ramosa; ramis adscendentibus acute tetragonis dense canescento-hirsutis; foliis bipinnatifidis, supra glabratis, subtus in venis et marginibus hirsutulis; inflorescentiis spicatis terminalibus pedunculatis; spicis usque ad 8 cm. longis densissime multifloris, ca. 3.5 cm. latis sub anthesin; corollis longe exsertis caeruleis.

Herb, many-branched from the base; stems and branches at first procumbent, later ascending, the tips erect, sharply tetragonal, rather densely hirsute with canescent hairs 1-1.5 mm. long and standing at right angles to the stems; leaves opposite, usually with several much reduced ones fasciculate in their axils; petioles 3-10 mm. long, alate-margined, hirsutulous; blades thin-chartaceous, uniformly green on both surfaces, bipinnatifid, ovate in outline, 2-5.5 cm. long, 2-6 cm. wide, often very deeply 3-parted to the base, with each division pinnatifid, all the lobes linear or narrowly oblong and subacute, glabrous above, hirsutulous along the venation and margins beneath; inflorescence spicate, terminal; peduncles 2-7 cm. long, densely canescent-hirsute like the stems; spikes at first subcapitate, later elongating to 8 cm., very densely many-flowered, about 3.5 cm. wide during anthesis (1.5 cm. wide exclusive of the corollas); bractlets narrow-lanceolate, 8-9 mm. long, long-attenuate to the setaceous apex, densely canescent-hirsutulous; calyx 6-7.5 mm. long, short-pubescent or sparsely short-hirsutulous, its teeth setaceous, 2-3 mm. long; corolla blue, its tube about 10 mm. long, its limb 11-13 mm. in diameter; nutlets 2-2.5 mm. long, reticulate.

The type of this very showy species was collected by Delzie Demaree (no. 17198)—in whose honor it is named—in chalk and marl ditches, Okolona, at an altitude of 350 feet, Clarke Co., Arkansas, on June 30, 1938, and is deposited in the Britton Herbarium at the New York Botanical Garden. This remarkable species combines the leaf-characters of *V. bipinnatifida* Nutt. with the large flowers of *V. canadensis* (L.) Britton and may prove to be a natural hybrid between them.

**Verbena hastata** f. **albiflora** f. nov.

A forma typica corollis albis differt.

This form differs from the typical form of the species in having white corollas instead of blue. The type was collected by Ellsworth Jerome Hill (no. 9.1888) in wet ground at Attica, Wyoming Co., New York, on August 8, 1888, and is deposited in the herbarium of the University of Illinois.

**Verbena lasiostachys** var. **scabrida** var. nov.

A forma typica foliis maturis supra valde scabridis recedit.

This variety differs from the typical form of the species in having its mature leaves decidedly scabridous on the upper surface.

The type was collected by Samuel Bonsall Parish (no. 11590) in a dry meadow at Monterey, Monterey Co., California, in August, 1917, and is deposited in the herbarium of Pomona College. The variety is known also from Los Angeles and Santa Cruz Counties, California.

**Verbena lasiostachys** var. **septentrionalis** var. nov.

A forma typica calyce toto 3-4 mm. longo recedit.

This variety differs from the typical form of the species in its calyx being in all only 3-4 mm. long. The type was collected by my good friend, Dr. Carl Clawson Epling (no. 5445) near Medford, Jackson Co., Oregon, in August, 1922, and is deposited in the herbarium of the University of California at Los Angeles. The variety is known also from Fresno, Lake, Mendocino, and Siskiyou Counties, California.

**Verbena simplex** var. **Eggerti** var. nov.

A forma typica caulibus multibrachiatis, ramis spicisque 25-35 elongatis dense multifloris differt.

This variety differs from the typical form of the species in its stems being abundantly branched to the base with some 25-35 branches per plant, each branch terminated by an elongated densely many-flowered spike.

The type was collected by Heinrich Karl Daniel Eggert—in whose honor it is named—at Pacific, Franklin Co., Missouri, on July 4, 1896, and is deposited in the Britton Herbarium at the New York Botanical Garden.

**Vitex Agnus-castus** var. **serrata** Moldenke, Geogr. Distrib. 40, nom. nud. (1939), var. nov.

Haec varietas a forma typica speciei recedit foliolis maturis valde serratis.

This variety differs from the typical form of the species in having its mature leaflets distinctly serrate along the margins. The type was collected by Theodorus Hendrik Arnoldus Jacobus Abeleven from a cultivated plant in the botanical garden at Nijmegen, Holland, and is deposited in the Rijksherbarium at Leiden. The variety has been collected several times in the Netherlands and also in Germany, always from cultivated material, and is to be expected in cultivation here.

**Vitex Negundo** var. **macrophylla** Moldenke, Geogr. Distrib. 40, nom nud. (1939); Prelim. Alph. List Invalid Names 51, hyponym (1940), var. nov.

A forma typica cymis dense multifloris, paniculis plerumque simplicibus ca. 3.5 cm. latis, floribus majoribus, et foliolis 3-7 majoribus differt.

This variety differs from the typical form of the species in its densely many-flowered cymes, mostly simple panicles about 3.5 cm. wide during anthesis, larger flowers, and more uniformly large and broad leaflets, which are 3-7 in number.

The type of this variety was collected by Eric Walther (no. 174) from a cultivated plant at the Huntington Botanic Garden, Huntington Park, Los Angeles Co., California, in October, 1929, and is deposited in the herbarium of the Bailey Hortorium at Cornell University. It has been widely confused with *V. Agnus-castus* var. *latifolia* (Mill.) Loud., but its distinctly stipitate cymes seem to plainly indicate that it is rather a previously undescribed variety of *V. Negundo* L. It has been collected in cultivation also in Massachusetts, New York, North Carolina, Puerto Rico, St. Thomas, and Switzerland. In the horticultural trade it often passes under the name *Vitex macrophylla*.

**Vitex Negundo** var. **sessilis** Moldenke, Geogr. Distrib. 40, nom. nud. (1939), var. nov.

A forma typica foliolis 3-5 sessilibus recedit.

This variety differs from the typical form of the species in having its 3-5 leaflets sessile. Its flowers are said to be light blue.

The type was collected by J. H. Heuer from a cultivated plant at Chapman Field, Dade Co., Florida, on August 27, 1931, [F. P. I. 63649], and is deposited in the herbarium of the Bailey Hortorium at Cornell University.

N. Y. Botanical Garden,
New York, N. Y.

# A New Species of Oak from Georgia

Wilbur H. Duncan

On May 26, 1940, in company with Professors G. N. Bishop and A. D. McKellar an oak was found growing in abundance on Buffalo Creek near Lexington, Georgia. At that time this oak was thought to be *Quercus imbricaria* Michx. Three months later on August 16 specimens bearing fruit were collected by the writer. The occurrence of mature fruit on the first year twigs indicated that the original identification was in error and that the tree belonged to the white oaks. Further studies verified this belief and raised a doubt as to whether the oak in question belonged to any described species.

Subsequent comparisons with numerous collections of white oak species and studies of available literature indicated that this tree had never been described. Following consultations with G. N. Bishop, professor of dendrology, School of Forestry, University of Georgia, and with Dr. C. H. Muller of the U. S. Dept. of Agriculture, it was decided that this oak should be described as a new species. The tree is named for the county in which it is most abundant and from which the type collection was made.

**Quercus oglethorpensis** sp. nov.

Arbor 25 m. alta, trunco 6 dm. crasso. Ramuli pubescentes, plerumque glabrescentes, brunnea-purpurei. Lenticellae albo-glaucae, conspicuae. Gemmae rotundae, 2.5 mm. longae. Folia decidua, 5-13 cm. longa, integra, elliptica vel obovata, basi acuta vel rotunda, apice acuta vel obtusa, marginibus parce revolutis, supra glabrosa, subtus pilis regulariter distributis, haud deciduis, luteolis, stellatis ornata. Petioli breves, robusti. Fructus hornotini, solitarii vel bini, sessiles vel pedunculati (ad 7 mm.). Poculum turbinatum, altum, circa $^1/_3$ partem glandis continens, squamis planis adpressis. Glans ovoidea, glauco-brunnea, adpresse pubescens, cir. 11 mm. longa.

Tree sometimes 6 dm. in diameter and 25 m. high, often beset with small, short branches near the base. Bark thin, light gray or nearly white and broken into thin, loosely appressed scales. Twigs at first pubescent, usually glabrate toward maturity; brown tinged with purple, becoming grayish the second season. Lenticels conspicuous (0.2-0.3 mm. in diameter), orbicular to slightly oblong in outline, light gray. Buds rounded, up to 2.5 mm. in length; bud scales thin, rounded to truncate at apex, erose and ciliate on margins, glabrous to appressed pubescent on back. Leaves deciduous, 5 to 13 cm. long, 2 to 4 cm. broad, entire (or on vigorous shoots occasionally undulate to shallowly sinuate near apex), narrowly elliptic to obovate in outline, some leaves tending to be falcate, acute to rounded at base, broadly acute to obtuse at apex, the margins slightly revolute, upper surface olive-green, glabrous, lower surface lighter green covered with evenly distributed, persistent, light yellowish, stellate, gland-less hairs over the entire surface including all veins, causing the lower surface to be velvety. Petioles short, stout, 2 to 7 mm. in length. Fruit solitary or paired, either sessile or on a peduncle sometimes up to 7 mm. in length, matur-

ing the first season. Cup turbinate, covering about one-third or more of acorn. Scales of cup flat, closely appressed, rounded to slightly truncate at apex, appressed pubescent on back, ciliate on margin, tan-colored with brownish band along margin. Acorn ovoid, gray-brown, appressed pubescent especially near apex, about 11 mm. in length.

Abundant in better drained bottomland areas of Wilkes, Elbert, and Oglethorpe Counties, Georgia. Appears to be confined to those bottomlands where the adjacent slopes are gentle.

GEORGIA—Oglethorpe Co.: Bottomland, Buffalo Creek, 8 miles E. of Lexington, Sept. 11, 1940, *Duncan 2870* (type as no. 89,011 in the herbarium of the National Arboretum); May 26, 1940, *Duncan 2548;* August 16, 1940. *Duncan 2722.* Wilkes Co.: "Medium-sized tree by roadside," June 14, 1919, *T. G. Harbinson* without number. Elbert Co.: Bottomland on Bond's Farm 8 miles S.E. of Elberton, Sept. 2, 1940, *Duncan 2861.*

Duplicates of the type collection have been deposited in the Gray Herbarium, Harvard University; United States National Museum; Herbarium of New York Botanical Garden; Herbarium of the Academy of Natural Sciences of Philadelphia; Field Museum, Chicago, Illinois; Duke University Herbarium, Durham, N. C.; University of Georgia Herbarium, Athens, Georgia; and Indiana University Herbarium, Bloomington, Indiana.

At a casual glance this oak might be mistaken for shingle oak (*Quercus imbricaria* Michx.). However, this confusion may be eliminated by considering the group to which each belongs. *Quercus oglethorpensis* most certainly is a member of the white oaks because there are no bristly tips on the leaves, the acorns mature the first season, the abortive ovules are near the base of the developed ovule, and the inner surface of the acorn shell is glabrous or only slightly hairy. It is therefore definitely excluded from the black oak group to which the shingle oak belongs.

*Q. oglethorpensis* might be confused with certain members of the white oak group. The entire leaves limit this number to a few species, namely, *Q. virginiana* Miller and possibly *Q. sinuata* Walt. (*Q. Durandii* Buckl.), *Q. austrina* Small, or *Q. Chapmanii* Sarg. This species may be distinguished from *Q. virginiana* by its deciduous leaves, purplish 1-year twigs, smaller fruit on shorter peduncles, and yellowish pubescence on under surface of leaf. It differs from *Q. austrina* in that the leaves are pubescent beneath, the scales of the cup are flat and closely appressed; from *Q. sinuata* in that the leaves are not whitish beneath and the acorn cup is deep and turbinate and distinctly not flat or "saucer-shaped"; from *Q. Chapmanii* in that the mature leaves are yellowish pubescent beneath, and that the scales of the cup are flat and not thickened.

The helpful criticisms and suggestions of G. N. Bishop, C. H. Muller, and others are gratefully acknowledged.

A general discusison of the tree, its associates and habitat is being prepared by Prof. G. N. Bishop and the author of the present article and is to be published elsewhere.

UNIVERSITY OF GEORGIA,
ATHENS, GEORGIA.

# Notes on Wisconsin Grasses-I

## Additions to the Grass Flora

L. H. Shinners

A number of grasses not reported from Wisconsin in Hitchcock's *Manual of the Grasses of the United States* have recently been found to occur in the state. Twenty-three of these are here recorded (starred in the list below), with notes on a few others of local occurrence. I am indebted to Mr. A. M. Fuller, curator, and Mr. E. P. Kruschke, assistant curator of botany at the Milwaukee Public Museum, to Mr. Charles Goessl of Sheboygan, and to Mr. Wells Oppel of Wauwatosa for the loan of specimens and for information concerning several species. In the following list a (W) refers to the herbarium of the University of Wisconsin, an (M) to the herbarium of the Milwaukee Public Museum.

**Bromus erectus* Huds.—Near cemetery, Sheboygan, Sheboygan Co., *Charles Goessl,* June 9, 1914 (Herb. Charles Goessl). Sheboygan, *Goessl,* June 10, 1921 (W).

**Bromus mollis* L.—Manitowoc, Manitowoc Co., *H. C. Benke,* June 18, 1913 (M). Roadsides, common, Rhinelander, Oneida Co., *Goessl* 2611, Sept. 1, 1915 (M).

**Bromus racemosus* L.—Seeded ground, Honey Creek Parkway at Menomonee River, Wauwatosa, Milwaukee Co., *W. W. Oppel & L. H. Shinners* 445, June 22, 1939 (W, M). Vacant lot, Florida and S. 1st Streets, Milwaukee, *Shinners* 1450, June 30, 1939 (W, M).

**Bromus japonicus* Thunb.—First reported by S. C. Wadmond from Delavan, Walworth Co.: Along roadside, Washington St. at Turtle Creek, city of Delavan, *Wadmond* 4136, June 28, 1936 (W). Now becoming common along railroads and roadsides in the southeastern part of the state: Roadway, U. W. Arboretum, Madison, Dane Co., *N. C. Fassett* 18756, July 5, 1937 (W). Along C. & N. W. R. R. 1/4 mile s. of Layton Ave., Cudahy, Milwaukee Co., *Shinners,* July 3, 1938 (W, M). Along C. & N. W. R. R. n. of Capitol Drive, Shorewood, Milwaukee Co., *Shinners* 784, June 18, 1939 (W). Roadway, west entrance to State Fair Park, West Allis, Milwaukee Co., *Oppel & Shinners* 786, June 24, 1939 (W, M). Along C. & N. W. R. R. s.w. of Madison, *Shinners* 432, June 11, 1939 (W).

**Festuca Myuros* L.—Sheboygan, *Goessl,* Aug. 11, 1914 (M).

**Festuca rubra* L.—Black River s. of Sheboygan, *Goessl,* July 4, 1935 (W).

**Festuca occidentalis* Hook.—Shaded ledges, not common, Sturgeon Bay, Door Co., *Goessl* 3735, June 9, 1916 (M).

*Puccinellia distans* (L.) Parl.—This plant is apparently becoming adapted to waste grounds. According to Hitchcock its usual habitat is "moist, more or less alkaline soil." In the summer of 1939 it was common along streets and in vacant lots in Milwaukee: *Shinners* 574 and 790, July 1939 (W, M). It has previously been collected at Green Bay, Brown Co., *J. H. Schuette,* June 22, 1882 (W); Sheboygan, *Goessl,* June 20-Aug. 26, 1914 (M), also *Oppel,* Sept. 4, 1937 (W); roadside just n. of Waukesha close to limestone quarries, Waukesha Co., *Shinners,* July 30, 1938 (W); and Reed St. R. R. yards, Milwaukee, *Oppel & Shinners,* Aug. 3, 1938 (W, M).

**Puccinellia Nuttalliana* (Schult.) Hitchc.—Roadsides and waste soil, occasional, Pensaukee, Oconto Co., *Goessl* 4082, June 21, 1916 (M).

**Eragrostis peregrina* Wiegand.—A recent introduction, common along streets in Milwaukee in 1939. Also beginning to appear along railroad tracks: C. M. & St. P. R. R. siding under Holton St. viaduct, Milwaukee, *Shinners* 575, July 11, 1939 (W). First collected in Wisconsin at Milwaukee in 1938: Edison St. Playground (with E. pectinacea), *Shinners,* July 31 (W); Edison and Knapp Streets opposite the coal docks, *Shinners,* Sept. 1 (W, M); Ninth St. beside Milwaukee Public Museum, *Fassett & Fuller,* Oct. 24 (W, M).

**Eragrostis poaeoides* Beauv.—C. & N. W. R. R. siding, Juneau Park, Milwaukee, *Shinners,* July 15, 1938 (W, M). Becoming common along railroad tracks in 1939: C. & N. W. R. R. n. of Capitol Drive, Shorewood, Milwaukee Co., *Shinners* 765, Aug. 4, 1939. C. & N. W. R. R. siding, Cudahy, Milwaukee Co., *Shinners* 707, Aug. 9, 1939. C. M. & St. P. R. R. station yard, Granville, Milwaukee Co., *Shinners* 1377, Sept. 10, 1939. Along C. &. N. W. R. R. just s. of Monona Bay, Madison, *Shinners* 858, Sept. 17, 1939. (All W, M).

**Eragrostis neomexicana* Vasey.—Railroad yards, Canal and 10th Streets, Milwaukee, *Oppel,* Sept. 17, 1937; a single plant, divided between Herb. Wells Oppel and the U. S. National Herbarium. (Det. Agnes Chase.)

**Catabrosa aquatica* (L.) Beauv.—Springs on sandy shore of Lake St. Croix, 6 miles s. of Hudson, St. Croix Co., *Fassett* 17629, Aug. 2, 1934 (W). Professor Fernald has identified the plant as *Catabrosa aquatica* var. *uniflora* S. F. Gray.

*Trisetum melicoides* (Michx.) Scribn.—This northern plant extends south as far as Cudahy, Milwaukee Co., where it is rather common in places in damp soil on the face of the lake bluffs: *Shinners* 903, Aug. 3, 1939 (W, M). Other Collections in Wisconsin are from Elkhart Lake, Sheboygan Co., *Schuette,* July 27, 1879 (W); Fort Howard (Green Bay), Brown Co., *Schuette,* July 30, 1881 (W); and The Ridges, Bailey's Harbor, Door Co., *Shinners,* Aug. 27, 1938 (W).

**Trisetum spicatum* (L.) Richt.—Occurs in northern Wisconsin as well as northern Michigan and Minnesota: Herbster to Port Wing, Bayfield Co., *L. S. Cheney* 6971, July 8, 1897 (W); and Port Wing to Orienta, Bayfield Co., *Cheney* 7333, July 14, 1897 (W).

*Ammophila breviligulata* Fernald.—On sandy beaches, shores of both Lake Michigan and Lake Superior. Beach of Jones Island, Milwaukee, *Mrs. C. T. Brues,* Sept. 10, 1908 (M). (Now extinct in that locality.) Dune, Town of Belgium, Ozaukee Co., *R. W. Pohl* 1155, Aug. 23, 1938 (W, M). Duneland, Town of Sevastopol, Door Co., *Pohl* 1111, Aug. 15, 1938 (W, M). On Long Island, Ashland Co., *Cheney* 5368, July 23, 1896 (W). Sandy shore of Lake Superior, Port Wing, Bayfield Co., *Fasset* 8078, Aug. 30, 1928 (W).

**Heleochloa schoenoides* (L.) Host.—First collected in the Reed St. R. R. yards, Milwaukee, *Oppel,* Autumn, 1936 (W). Becoming established in vacant lots in neighboring parts of the city: *Shinners* 702 and 709, Aug. 7, 1939 (W).

**Muhlenbergia asperifolia* (Nees & Mey.) Parodi.—Reed St. R. R. yards, Milwaukee, *Oppel,* Oct. 1, 1937 (W). Railroad yards, Sheboygan, *Goessl,* Aug. 23, 1938 (W).

**Muhlenbergia mexicana* (L.) Trin.—Has been collected in Dane, Grant, Vernon, Buffalo, and Pierce Counties (W), and in Dunn County (M). The awned form, forma *commutata* (Scribn.) Wieg. ("var. commutata Scribn." of Hitchcock's Manual; it was published as a subspecies), is more common and widespread. It has been collected in Grant, Rock, Green, Racine, Jefferson, Dane, and Waupaca Counties (W), and in Milwaukee, Dodge, and La Crosse Counties (M).

**Muhlenbergia sylvatica* Torr.—The ordinary form is apparently rare: Blue Mounds, Dane Co., *T. J. Hale* (no date, but probably 1860 or shortly before) (W); Prairie du Sac, Sauk Co., *J. J. Davis,* Aug. 22, 1922 (W). The awnless form, forma *attenuata* (Scribn.) Palmer & Steyermark (Ann. Mo. Bot. Garden 22:467, 1935), is occasional throughout the state: Dane, Grant, Crawford, Vernon, Burnett, and Bayfield Counties (W), and Barron, Langlade, Oconto, and Waupaca Counties (M). This form may deserve varietal rank. In addition to the absence of awns and the difference in range, the panicle is denser, sometimes suggesting slender individuals of *M. foliosa.*

**Sporobolus asper* (Michx.) Kunth.—First collected in Wisconsin along the C. M. & St. P. R. R. at Hoyt Park, Wauwatosa, Milwaukee Co., *Oppel,* Sept., 1936 (Herb. Wells Oppel). It is now becoming established along railroads, sometimes growing for miles along the right-of-way. Along C. & N. W. R. R. s.e. of Granville, Milwaukee Co., *Shinners,* Aug. 21, 1938 (W, M). C. & N. W. R. R. North Milwaukee, *Shinners* 904, Sept. 10, 1939 (W). Along C. & N. W. R. R. tracks about 3 miles s.w. of Madison, Dane Co., common for 4 or 5 miles along the tracks, *Shinners* 857, Sept. 17, 1939 (W). Along C. M. & St. P. R. R. between Madison and Middleton, *Shinners* 1101, Oct. 21, 1939 (W).

**Oryzopsis canadensis* (Poir.) Hitchc.—Rocky soil, Neillsville, Clark Co., *Goessl,* May 7, 1915 (Herb. Charles Goessl). Sterile soil, fairly common, Trow, Clark Co., *Goessl* 1280, July 15, 1915 (M). Vilas Co., *Cheney* 819, June 26, 1895 (M). According to Cheney's notebook, no. 819 was collected "between Conover and Eagle River along Wis. River."

**Aristida basiramea* Engelm. var. *Curtissii* (A. Gray) Shinners. (*A. Curtissii* Nash). See Amer. Midl. Nat. 23:633, 1940.—Observatory Hill, Montello, Marquette Co., *Fassett & McLaughlin* 14945, Sept. 18, 1929 (W). Granite outcrop, Marquette, Green Lake Co., *Shinners,* Sept. 26, 1937 (W). Growing in clefts in sandstone, Ridgeway, Iowa Co., *Pohl* 1257, Sept. 24, 1938 (W, M). Picture Rock, Dane Co., *Shinners* 245, Oct. 2, 1938 (W, M).

**Aristida oligantha* Michx.—I. C. R. R. tracks between Charter and Randall Streets, Madison, Dane Co., *Fassett* 15933, Sept. 26, 1933 (W). (Apparently not persisting.) C. & N. W. R. R. yards, New Butler, Milwaukee Co., *Oppel,* Aug. 27, 1938 (W, M). C. M. & St. P. R. R. yards between Main and Doty Streets, Madison, abundant for about 50 feet along one siding, *Shinners* 891, Oct. 1, 1939 (W, M).

**Leptochloa fascicularis* (Lam.) A. Gray.—Farm yard, Oconomowoc, Waukesha Co., *Oppel,* Oct. 30, 1937 (W). (Det. Agnes Chase.)

*Panicum linearifolium* Scribn.—Dry open woods w. of New Coeln, Milwaukee Co., *Shinners* 1089, June 17, 1939 (W, M). Represented in the University Herbarium by only two other collections: Belmont, Lafayette Co., *Fassett* 15079, May 31, 1930 (W); and sand plain, Wisconsin Rapids, Wood Co., *Fassett* 7320, Aug. 26, 1928 (det. Agnes Chase) (W).

**Panicum dichotomiflorum* Michx.—Now a widespread weed in the southern part of the state. Sheboygan, *Goessl,* Sept., 1914 (M), also Sept., 1934 (W). Roadside, Coon Valley, Vernon Co., *J. B. Marks,* Aug. 19, 1939 (W). Muscoda, Grant Co., *Davis,* Sept. 20, 1934 (W). Cornfield, Mississippi River bottoms, McCartney, Grant Co., *Fassett* 17707, Sept. 28, 1934 (W). Weed in sandy cornfield, Black Earth Creek, Arena, Iowa Co., *Fassett* 14260, Sept. 7, 1931 (W). I. C. R. R. e. of Park St., Madison, Dane Co., very common, *Shinners* 860, Sept. 17, 1939 (W). C. & N. W. R. R. freight yards, Watertown, Jefferson Co., *Pohl & Shinners* 907, Sept. 4, 1939 (W). Reed St. R. R. yards, Milwaukee, *Oppel,* Oct. 1, 1936 (det. Agnes Chase) (M). Railroad yards, common, Milwaukee, *Oppel,* Oct. 1, 1937 (W). Waste heaps, Jones Island, Milwaukee, *Pohl* 1224, Sept. 6, 1938 (W, M). Vacant lot, Orchard and S. 1st Streets, Milwaukee, *Shinners* 781, Aug. 20, 1939 (W). C. &. N. W. R. R. yards, New Butler, Milwaukee Co., *Pohl & Shinners* 907, Sept. 4, 1939 (W).

UNIVERSITY OF WISCONSIN,
MADISON, WIS.

# Den and Runway System for Weasels and other Small Mammals in the Laboratory[1]

Thomas Hume Bissonnette and Earl E. Bailey[2]

Unsuccessful attempts, in 1937, to keep weasels in good condition for studies on photoperiodicity of sexual and pelt cycles, in laboratory cages which had proved successful with ferrets, led us to seek a more satisfactory arrangement. At the Wilson Mink Ranch, Somers, Connecticut, dens and runways used with mink by Bissonnette and Wilson (1939),[3] in their experiments, and by Wilson in commercial mink raising for pelts, were observed. Although the system in vogue there was planned for outside use, Bissonnette and Wilson easily adapted it for use in a cellar.

It has been adapted further for use with weasels and other small mammals. With it eleven weasels of two species, Bonaparte's weasel (*Mustela cicognanii cicognanni* Bonaparte), and the larger New York weasel (*M. frenata noveboracensis* (Emmons)) have been kept in good condition from May through November, with loss of only two by death, and none by actual escape from the room. Three weasels escaped from the pens into the room early in their confinement but were recaptured alive in traps. The pens were then further adapted to meet their challenge. The deaths were attributable to swallowing either pieces of glass broken from the drinking vessels, used, at first, unprotected from the teeth of the animals, or slivers of wood from gnawing the cages, or both. Other animals were broken of the habit of breaking the glass by making troughs of wire to enclose the ends of the vessels intruding into the runways.[4] This prevented the animals from grasping the glass rims and breaking them. Other changes in details of the system have finally evolved the dens and runways to be described below. Further changes can be made as needed.

The dens are wooden boxes, with removable covers of plywood which fit under cleats at the ends next the runway. Each cover is held in place by a two-inch wire nail pushed down through it so that the nail comes down inside the box at the other end. This prevents the weasel from raising the cover after pushing it free of the cleat. The cover is not "light-tight," but admits some light around its edges. Under this is a false top consisting of a wooden frame fitting just inside the box, resting on two cleats, and covered by ½-inch galvanized soldered wire mesh firmly fixed along the sides. This false top is held in position by two wire finishing nails passed through holes in the sides of the box and into holes in the edge of the top at opposite end on the two sides. These are removable for housecleaning. (For use outside, exposed to rain, the real top must be made water-tight and fit down over the house on the outside.) Indoors, only the sliding board top is used, to admit air and some little light to the den. The beams of light encourage the animals to tear at the wire, and spread it enough to permit escape into the room. In such cases, a second layer of wire mesh is put on the under side of the false top. Frequent inspection for gnawing or spreading of the wire of the box and runway are the price of security with weasels, for they are persistent in trying to escape.

The interior of the box is divided by a wooden partition for half its height into a bedchamber, with shavings and excelsior for nesting, and a hallway, from which a two inch round opening or doorway is continuous with a similar doorway in the runway.

1 Aided by a grant from the Penrose Fund of the American Philosophical Society, 1938-9, administered by T. H. Bissonnette.

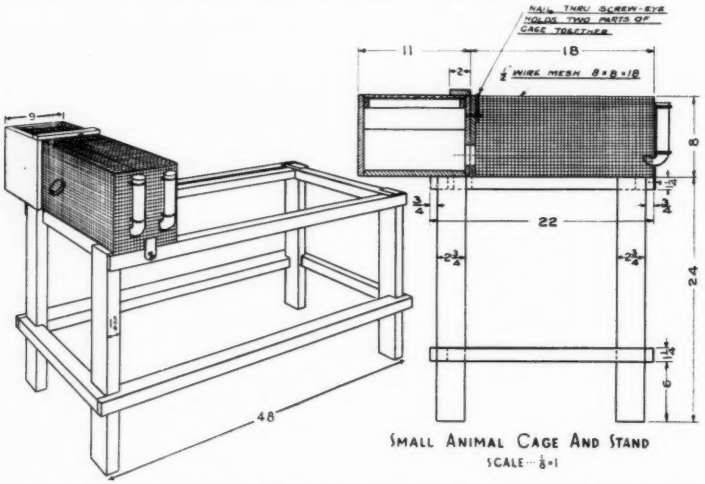
2 We are grateful to Mr. Howard Carter Wiley who made the figures for this paper.

3 T. H. Bissonnette and E. Wilson, Science **89**(2314):418-19, 1939.

4 Since the above was written it has been found necessary to enclose the lower drinking part of the glass in copper tubing with opening over the one in the glass to prevent the animals from breaking the glass, which is now completely shielded. The tube is too long and narrow to permit escape.

This hallway also serves partly as a dining-room where the meat course is consumed after it is snatched from the wire, or small animals are taken to be eaten at leisure.

A little above center, in the side of the house next the runway, an eyebolt is fastened with the eye projecting outside the box to pass through a slot in the wooden end of the runway. A three-inch wire nail is passed down through the eye inside the runway to hold house and runway firmly together. Dimensions are shown in Fig. 1.




SMALL ANIMAL CAGE AND STAND
SCALE — ⅛=1

The runway is of ½-inch galvanized wire mesh for top, bottom, sides and one end, securely wired together with overlap to prevent tearing apart by the animals. The end next the "house" is of wood with a two-inch round hole leading to the door of the hallway and a slot for the passage of the eyebolt as described above. Dimensions are given in Fig. 1. A platform at the end of the runway remote from the house, similar to that used for sunbasking by mink, was used at first, but was taken out later because the weasels used it for an outhouse instead of a sunparlor and it was hard to clean. A short metal strip extends vertically downward from the bottom of the wire end of the runway. A hole in it fits over a nail in the supporting rack to keep this end of the runway from upsetting, because of the overhang of the house at the other side of the rack.

Two drinking vessels per cage are used, one for milk, the other for water. They consist of 1½-inch glass tube drawn out at one end to ½-¾-inch diameter and bent at right angles. They are placed with the larger part vertical and the curved part projecting through small openings in the wire near the bottom of the end of the runway. The upper end is tightly closed by a rubber stopper. Each vessel has an opening in the upper surface of its narrow horizontal part, for drinking. Each is kept in place by two small wire springs stretched across it near its top and bottom and fastened to the wire mesh on each side. (Fig. 1). The bottom spring is needed to keep the weasels from pushing the glass tube from the hole in the wire to escape. The drinking vessels are obtainable from Geo. H. Wahmann Co., of Baltimore, Maryland.

These double units (house & runway) are placed side by side in groups of five, across racks, each consisting of a wooden frame standing on four legs with large casters, as shown in Fig. 1.

Advantages for the system here described are as follows: The grouping on racks with casters gives easy mobility on cement floors for cleaning and washing up droppings. A group of five units is small enough to be easily handled and suitable for experiments

on small numbers of animals, caged individually but treated similarly. Two, four, or six groups can be used as controls and experimentals, as needed. The wire runways can be cleaned and disinfected easily by dipping into boiling water and effective solutions, or by rapid flaming. The houses can be opened and dipped, or otherwise cleaned, aired and sunned. The animals can be changed easily from one combination of den and runway to another, by slipping a shingle or metal plate between the house and runway, to cover the doors, and holding it tight to the member containing the animal while removing the wire nail, freeing the eyebolt, and separating the compartments. The one containing the animal can then be moved and hooked up in any desired combination with another runway or house by pushing the nail down after the eyebolt is passed through the slot. Matings may be controlled in this way without handling the animals. Animals may also be taken to glass-sided boxes for photographing. With careful daily inspection of wire and "house"-tops, the animals can be kept from escaping. The units for several animals take up little space and afford flexibility of arrangements compatible with a variety of uses or animals. They are particularly adapted for use with very quick animals whose perseverence in attempts to escape is too great to allow doors to be opened in the usual way.

TRINITY COLLEGE,
HARTFORD, CONNECTICUT.

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## Book Reviews

ADAPTIVE COLORATION IN ANIMALS. By Hugh B. Cott. Oxford University Press, New York, 1940. xxxii + 508 pp., 48 pls., 84 text figs. $8.50.

Dr. Hugh B. Cott, University Museum of Zoology, Cambridge, carries the study of color-adaptation well beyond controversy in this remarkably full book. The previous lack of such a comprehensive work may account in part for the anti-adaptation, anti-selection school which is now conspicuous among biologists, particularly in the United States, and still more so in experimental laboratories. Says Julian S. Huxley in his introduction: "Dr. Cott, in this important book, has turned the tables with a vengeance on objectors of this type. He has shown that it is they who are the armchair critics, or, one might say, the laboratory-bench critics. Had they taken the trouble to acquaint themselves with even a fraction of the relevant facts to be found in nature, they could never have ventured to enunciate such sweeping criticisms: their objections are a measure of their ignorance."

The contents fall in three sections: concealment, advertisement and disguise among animals, each plentifully divided and subdivided so that one has no difficulty in locating a desired topic or seeing its relation to the rest. For example, Part I, on Concealment, contains first a large section on *methods* of concealment in nature, under which we find (1) general color resemblance, with subheadings, (i) general resemblance in different environments, (ii) convergence in color resemblance: common cryptic coloration, (iii) adaptive radiation in color resemblance; and so on. The *function* of concealment comes next, with an analysis of objections and evidence bearing on the theory of concealing coloration.

Insects and vertebrates receive, naturally, most of the attention since they predominate in the visible world. Subterranean animals, internal parasites and microscopic forms do not, in general, show special adaptive coloration. Clear analysis is perhaps the most important feature of the work, for the author shows, as thoroughly as words and illustrations can show, how color-adaptation forms an integral part of our objective world of lights, shadows, colors, shapes and patterns. The optical principles are simple ones; the variety of ways in which they work is immense. As Dr. Cott says, his book offers "a body of evidence which makes it appear that adaptive coloration is one of the chief attributes of higher animals, and has been, indeed, one of the main achievements of organic evolution."

The cumulative weight of his vast array of examples cannot fail to impress any reader. The bibliography contains 685 titles. There is an abundance of excellent

photographs and line drawings, nearly all original and highly pertinent. All types of evidence are considered, including the most recent experiments, statistical treatments and optical-psychological data. Carefully and fully he answers objections. Most refreshing is the unfailing clarity of his argument.

If anything is lacking in the subject-matter it is, perhaps, a discussion of transparency as a form of deception, and a full treatment of structural and functional modifications upon which those of color often depend. But he mentions all these. It may be too much to hope that this book will arouse a widespread appreciation of adaptive evolution as a reality, but at least it deserves to be read by field naturalists and armchair objectors alike.—THEODORE H. EATON, JR.

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O. C. MARSH, PIONEER IN PALEONTOLOGY. By Charles Schuchert and Clara Mae LeVene. Yale University Press, New Haven, 1940. xxi + 541 pp., 30 pls., 33 figs. $5.00.

In 1851 a surprisingly immature lad of twenty entered the Phillips Academy at Andover, Massachusetts—to spend half his time playing backgammon and more in shooting ducks. A year later that lad decided to study; in 1856 he entered Yale University where, as nephew of a very rich man, he spent $726 to $920 per year instead of the $300 which ordinary students needed. In 1865 this lad, now industrious and matured by study in Europe, became professor of paleontology at Yale—the first professor of that subject in any American college and the second one in the world.

Thus began the scientific career of O. C. Marsh, one of the three heroic figures in American paleontology, Hall and Cope being the others. Both have received biographical treatment, Osborn's study of Edward Drinker Cope being a specially competent piece of work. The present volume completes the trio. It also is semi-official, for its senior author followed Marsh as professor of paleontology at Yale, while the junior author long had charge of the Marsh library, diaries and letters.

Many official biographies are dull, apologetic affairs which do not try to present their subjects as vital human beings. That does not apply to this study of Marsh. It is true that it does not make its subject warm and lovable; but the fault (as George Gaylord Simpson has remarked) lies with Marsh, who was neither a warm nor lovable man. He was formal, egocentric, reserved, suspicious and a readier enemy than friend. He also had the arrogance that often goes with unearned wealth, for as nephew of the rich George Peabody, Marsh could live handsomely without a salary from Yale.

Schuchert and LeVene frankly admit these defects, showing how they affected Marsh's scientific work. They also call attention to the growing habit of procrastination which left most of Marsh's research unfinished when he died in 1899. Since many of these unfinished studies were embodied in lithographs but not notes, the scientists who took up where Marsh left off had to begin almost *de novo*. It is not surprising, therefore, that some projects, such as the monographs on theropod and ornithopod dinosours planned in 1885, never were brought to completion.

This biography devotes 93 pages to Marsh's early life and to George Peabody, who provided the wealth with which Marsh built up one of the world's great collections of fossils. Four chapters of 114 pages deal with early expeditions to the West and with Marsh's collectors; the most sprightly pages, perhaps, are those on the Red Cloud crusade of 1874-75, in which Marsh forced the resignation of a Secretary of the Interior under whom the Sioux and other Indians were being shamefully cheated. It is not often that professors have such courage as Marsh showed in attacking the "Indian ring," nor the financial, social and political contacts to make their courage effective.

Another interesting chapter is devoted to the early history of the U. S. Geological Survey and the steps by which Marsh became its paleontologist and then was forced out of service. Here are echoes of the quarrel with Cope, a quarrel that reached epic proportions and that also figures in the chapter on Marsh's laboratory assistants. Here again the authors are perfectly frank, admitting the faults by which Marsh made enemies of his helpers. Though those conflicts have no importance today, they undoubtedly had great influence upon vertebrate paleontology between 1880 and 1900.

Four chapters—139 pages—review Marsh's scientific *work*, as distinguished from his scientific *activities*. They show his amazing ability as a systematist, since he contributed greatly to the classification of reptiles, birds and mammals. They also provide the modern student of vertebrate paleontology with hisorical sidelights upon many of the species and larger groups that figure in every textbook.

In short, *O. C. Marsh, Pioneer in Paleontology* is both a contribution to the history of science and to the history of these United States between 1830 and 1900. That many of its chapters are thoroughly good reading gives it added value. Marsh did not confine himself to the narrow paths of paleontology; it is well that this biography of him is not too restricted in its audience.—CARROLL LANE FENTON.

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THE MICROSCOPIC WORLD. By Frank Thone. Julian Messner, Inc., New York, 1940. 245 pages. $3.

In this age of science, when the microscope has become an indispensible tool in the professions and the industries, it is difficult to realize that to many individuals it still remains an instrument somewhat shrouded in mystery, capable of opening up a weird and unfamiliar universe. To these non-technical lookers-through-the-microscope come the same thrills which stirred Leeuwenhoek and the legions of amateur microscopists succeeding him down through the closing decades of the nineteenth century. Many of these amateur microscopists became pioneers in the refinement of the microscope while others contributed fundamentally to the growth of the new sciences of Protozoology, Bacteriology, Histology, Embryology, Parasitology and the many other diverse branches of Biology and optics which awaited the development of the compound microscope. In recent years, there have been so many forms of diversion clamoring for attention that few individuals are drawn to microscopy as a non-professional hobby. This situation is in sharp contrast to that which maintained in the hey-day of amateur microscopy when every liberally educated person was intrigued by the uncultivated fields which only the microscope could reveal. Popular interest in this field contiguous to science on the one side and to amusement on the other has lapsed and thereby Biology has lost a valued by-path for building of intelligent understanding and appreciation among non-technical laymen. Dr. Thone's "The Microscopic World" will be welcomed by Biologists as another agency for reenlisting wider interest in Biology through an attractive and strictly popular presentation of the marvels of microscopic life.

Fascinating beauty and sound facts in non-technical narration are ingeniously woven into the volume. Excellent photographs and drawings of microscopic organisms and of models from some of the famed museum exhibits are the chief sources from which the illustrations have been selected.

In addition to the presentation of facts of Biology at the elementary level, Dr. Thone has introduced the reader to some of the most advanced fronts of biological investigation. He projects the mind of the reader in a preview of the problems and possible advances that lie ahead in the uses of the ultramicroscope, the electromicroscope, and the ultracentrifuge. He carries the reader to the threshold of varied new approaches to old problems in his discussion of recent inventions and of the crystalline form of the viruses. In much of the narration, he introduces the names of research workers with an informality and a freedom which convinces the reader of the reality of the men and of their works rather than leaving the problems hung up as abstruse matters to be viewed by the uninitiated only from a safe distance.

The usefulness as well as the damage wrought by microrganisms is discussed and to the leavening power of the yeasts is added a vein of wit and humor which render the book wholesome and enjoyable reading.—HARLEY J. VAN CLEAVE.

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TEXTBOOK OF PALEOBOTANY. By William C. Darrah. D. Appleton-Century Co., New York, 1939. xii + 441 pp., 180 figs. $5.00.

Despite its inherent significance and continually increasing knowledge "Paleobotany" is not yet regarded as an essential part of the training of botanists. This circumstance, deplorable as it is, constitutes undoubtedly a real reason for the paucity, if not actual absence, of textbooks suitable for courses in this subject. To have provided such a textbook is the distinct merit of the author.

The scope of the book is necessarily broad making the proper allotment of space a difficult problem which the author seems to have solved well. Part One (pp. 3-52) is devoted to a discussion of general principles, both geological and biological; Part Two (pp. 55-304) is entirely confined to "The Paleontological History of the Vascular Plants"; Part Three (pp. 307-376) records the development and "Succession of Ancient Floras," whereas Part Four (pp. 379-421) concludes the book with three chapters on "Fossil Thallophytes and Bryophytes," "Concepts of Paleobotany" and "A Reasonable Phylogeny of Vascular Plants." Selected bibliographies accompany the individual chapters.

The large number of illustrations is very commendable in view of the general inaccessibility of many specimens. Unfortunately their preparation and reproduction are not quite in keeping either with the original sources or the material illustrated. This deficiency is regrettable but can certainly be corrected in a future edition.

Because the paleontological record will always remain incomplete the history of plant life likewise can never be told in its entirety. Yet pessimism need not disturb us in the face of the many highly significant discoveries made especially during recent years. At the same rate of progress the future is bound to bring unexpected solutions to many problems still confronting the morphologist and the phyto-geographer. There is also the possibility that some phylogenies may in the course of time appear less "reasonable" than now.—THEO. JUST.

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THE FERNS AND FERN ALLIES OF WISCONSIN. By R. M. Tryon, Jr., N. C. Fassett, D. W. Dunlop, M. E. Diemer. Published by the Department of Botany, University of Wisconsin, Madison, Wisconsin. 1940. v + 158 pp., frontispiece, 214 figs., 76 maps. Cloth $1.00.

Customarily floras or manuals include all vascular plants found in a given area whether politically or geographically circumscribed. In recent years however botanists of Wisconsin have departed somewhat from this practice with the present volume representing the last in a series of special treatments of particular families or groups.

Instigated and financed by Mr. Martin J. Gillen, an alumnus of the University of Wisconsin and an ardent conservationist, "The Ferns and Fern Allies of Wisconsin" is the outgrowth of a joint enterprise in which each of the four authors contributed his share. A total of 118 native species, varieties, forms and hybrids of ferns and fern allies received adequate and up-to-date treatment including numerous illustrations and maps showing their distribution in the state. Written in response to a growing public interest in these plants this book meets not only the needs of the amateur but also the expectations of the professional botanist in Wisconsin and neighboring states.

—THEO. JUST.

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THE COMPLETE GUIDE TO SOILLESS GARDENING. By W. F. Gericke. Prentice-Hall, Inc., New York. 1940. 285 pp., 66 figs., 10 tables. $2.75.

The author is one of the first to recognize and investigate the practical application of solution culture and is largely responsible for the widespread interest in this field. Before turning to this application, he had spent years investigating the mineral nutrition of plants, hence his treatment of the subject is both scientific and practical. He is an exponent of the tank method of culture and devotes his attention largely to this method. Other workers, while admitting he possible superiority of the tank method in California

with its abundant sunlight, find the sub-irrigation method of Withrow more satisfactory in regions where there are several consecutive cloudy days. Directions are given for the preparation of basins, supporting mats, and nutrient solutions, for solution testing and renewal, and for the general care of cultures. Over a hundred pages are devoted to specific crops including, tomatoes, cucumbers, watermelons, squashes, potatoes, parsnips, carrots, beets, turnips, radishes, onions, head lettuce, cabbage, parsley, spinach, chard, peas, corn, beans, strawberries, wheat, asparagus, rhubarb, and artichoke.

—N. L. NOECKER.

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SOILLESS CULTURE SIMPLIFIED. By Alex Laurie. McGraw-Hill Book Company, New York. 1940. 201 pp., 22 figs., 7 tables. $2.50.

This is an excellent book written by a professor of floriculture at Ohio State University who has had considerable experience growing plants both with and without soil. More than half of the book is devoted to the fundamental principles of soil culture, making it very valuable to any grower of plants. This extensive discussion of plant growth in soil has a specific end in view, namely, to familiarize the reader with the necessary fundamental factors involved, since the discussion of crops grown without soil is but an application of the same principles. The author makes it clear that plants develop under similar conditions, whether grown in soil, in water, or in some inert substance plus water. He describes these various methods clearly and adequately. He favors what is commonly called the subirrigation method, which involves the use of an inert substrate, and recommends specifically a commercial product, "Haydite," which he has reason to feel is much superior to cinders or gravel for the purpose. The book is written primarily for the commercial grower but it should serve the amateur equally well.—N. L. NOECKER.

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GROWING PLANTS IN NUTRIENT SOLUTIONS OR SCIENTIFICALLY CONTROLLED GROWTH. By Turner, Wayne I. and Victor M. Henry. John Wiley & Sons, Inc., New York. 1939. 154 pp., 3 pls., 29 figs. $3.00.

The authoors are to be highly complimented on this excellent contribution to the field of soilless agriculture. The subject matter is reliable, complete, and presented in such a manner as to be readily understood by any intelligent reader. Each of the various methods of culture is described, but the emphasis is placed upon the sub-irrigation method which the authors feel is far superior to the others. Very specific directions are given for constructing the necssary equipment, making up cultuure solutions, and growing the plants. Careful attention is given troublesome problems which are sure to be encountered in this type of plant culture. New information is presented regarding the potassium-nitrogen balance which was found to be dependent upon light conditions and seasons of the year. Charts for the proper concentrations of these elements in the solutions during the various months of the year are given for roses, carnations, and tomatoes. This book should serve as a helpful guide to the amateur, the commercial grower, or the research worker.—N. L. NOECKER.

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PLANT CHEMICULTURE, A GUIDE TO EXPERIMENTS IN GROWING PLANTS WITHOUT SOIL. By C. D. Dawson and M. V. Dorn. 3rd revised ed. Published by the authors, Los Angeles. 1939. 130 pp., 17 figs.

This book is now in its third edition, the first edition being one of the earliest if not the very earliest in the field of soilless gardening. The authors have had considerable experience growing plants in nutrient solutions in their laboratory and on the basis of their success are enthusiastic exponents of this method of culture. They write largely from their own experience presenting their story in such a way that it can be readily understood by readers unfamiliar with scientific terminology. Much more attention is given to the tank method of culture than to the aggregate or sand methods; however, a number of good references pertaining to the latter methods are included in

the bibliography. The book is reliable, brief, yet sufficiently complete to be of great help to the amateur gardener.—N. L. NOECKER.

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GARDENING WITHOUT SOIL. By A. H. Phillips. The Chemical Publishing Company, Inc., New York. 1940. 137 pp. 8 figs. $2.00.

This little book is excellent throughout. In spite of its small size it is surprisingly complete. Nearly all of the essential aspects of soilless culture are adequately discussed. The treatment of the subject is conservative and indicates the author's proper evalution of the facts obtained by personal experience and world-wide study. Both general methods of culture, tank and aggregate, with the various modifications of each are described, and diagrams of apparatus for both large and small scale operations are included. Correct emphasis is placed on the importance of root temperature; for most plants the best temperature for the roots is between 70° and 75° Fahrenheit. A number of good references are included in the bibliography.—N. L. NOECKER.

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SOILLESS GROWTH OF PLANTS. By Ellis, Carleton and Miller W. Swaney. Reinhold Publishing Corporation, New York. 1938. 155 pp., 58 figs. $2.75.

This book is one of the early ones in its field and is now in its third printing. It opens with a chapter on the elementary chemistry of plant life. The following chapters give a fairly complete account of the three recognized modifications of soilless growth namely, water culture, sand culture, and sub-irrigation systems. Numerous household experiments have been included, liberally supplemented with photographs. Some space is devoted to a consideration of large scale operations being carried on at the present time. Several of the nuttrient formulas used in various laboratories are given. One chapter is concerned with a brief discussion of the effect of several special chemicals on plant growth. As a whole the treatment of the subject is sufficiently complete to serve as a helpful guide to the amateur gardener.—N. L. NOECKER.

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GROWING PLANTS WITHOUT SOIL. By D. R. Malin. The Chemical Publishing Company, Inc., New York. 1940. 137 pp., 19 figs., 1 pl. $2.00.

Now revised and in its second edition, this book is an elementaary guide for the growth of plants in nutrient solutions, based largely upon the author's experience at a Los Angenels high school. There are short chapters on germination, solution formulas, aeration, acidity, sand cultures, tank construction, tests for common metals, symptoms of nutrient deficiency and excess in plants, and several other less important subjects. The material presented should be of interest to the beginner who is growing plants as a hobby.—N. L. NOECKER.

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FRENCH-ENGLISH SCIENCE DICTIONARY for Students in Agricultural, Biological and Physical Sciences. By Louis De Vries. McGraw-Hill Book Company, New York, 1940. viii + 546 pp. $3.50.

Prepared as a companion to the author's earlier "German-English Science Dictionary" the present volume covers the same fields but contains a carefully prepared bibliography and 73 additional pages although there are about 5000 less entries. Years of teaching provided the author with invaluable experience in his efforts to remove the most commonly encountered difficulties by the inclusion of information ordinarily not expected of a "Science Dictionary." This feature is bound to contribute largely to the book's usefulness which might be enhanced by the addition of such important terms as *chondriome*, *plastidome*, and *vacuome*. Professor De Vries has done a real service to students and advanced workers alike by furnishing them with these handy and reliable tools necessary for a better understanding of scientific work published in French or German.—THEO. JUST.

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# The American Midland Naturalist

Devoted to Natural History, Primarily
that of the Prairie States

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